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Telephone: Central 1885. Telegrams: CIRA

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The Elasticity of Cast Iron

The development of high-duty cast irons and of alloy cast irons and their use for many stressed engineering parts, necessitates a better knowledge of their properties. The elasticity of cast iron is an inherent property to which too little attention has been paid, and there is need of a standard method for its determination. Wrought iron and steel may be said to be truly elastic over a range of stress, and by using instruments of sufficient accuracy and precision it is possible to determine the elasticity over this range and thereby the modulus of elasticity. Cast iron, however, differs from wrought iron and steel in possessing no well-defined elastic range in which the stress-strain relationship holds, hence the difficulty in determining the elastic modulus in tension, and elastic determinations have therefore to be made on transverse bars, where strains or deflections of greater magnitudes are more easily measured.

Recent work by Pearce has shown that the deflection in transverse of grey cast iron and malleable cast iron comprises two components, elastic deflection and plastic deflection or permanent set, and that elastic deflection differs comparatively little from iron to iron. It is suggested that the elastic modulus of cast iron should be calculated on the elastic deflection at the fracture of a standard bar, regarding the point of fracture in the same way as the limit of proportionality is regarded in wrought materials. This method of evaluating the elastic properties differs from that used by Mackenzie in America, who determined the modulus of elasticity by calculation from the deflection of a rectangular transverse bar at an arbitrary load of 1,000 lbs. or at the final breaking load; or from the method of Thum and Ude in Germany, who determine the same property by dividing the transverse rupture stress by the total deflection at fracture.

These various methods of determination do not allow of comparison between the work of one observer and another, and there is a strong necessity for a standard international test for the evaluation of this property. If a standard test, such as is suggested by Pearce, were adopted, more reliable data would be obtained regarding the influence of composition, structure, alloy additions, and heat-treatment upon the elastic properties of cast iron. Such a test is more necessary than ever at the present time, in view of the work which is being done on alloy cast irons and on the hardening of cast iron, and particularly if designers and engineers are to have the information which will enable them to make a wider application of such materials.

Accidents in Factories

The question of accidents in factories is one concerning those organising and supporting the recent International Congress in London on Scientific Management, attended, it is stated, by some 2,000 delegates from over thirty countries and receiving some 200 Papers. The congress focusses attention on the scientific approach in managing any enterprise, especially in industry and commerce. It is one of the paradoxes of efficiency that the scientific approach is the human approach, because human beings are involved at every stage of the productive process, and their interests, sympathies and welfare, if ignored, spell failure in management. In fact, successful management produces its success by lining up with least waste these interests and sympathies to yield a maximum result.

The Chief Inspector of Factories, in his annual report, has stressed two things: the increase in accidents in industrial occupations, and the high accident rate among young people. As it is best to solve these problems by mutual goodwill and because legislation is necessarily cumbrous and slow, changes in industry taking place every day, the Home Office is convening in the autumn a conference of employers, through their representative organisations. There the whole matter will be discussed and remedies sought, both educational and preventive. The available statistics should show where extra prevention is required. The steady increase in occupational accidents and diseases is doubtless due in part to the increasing activity in industry and in part to the introduction of new methods and processes the effects of which on workers cannot altogether be predicted. Sand blasting and chromium plating occur as illustrations. There are also "accident-prone" operatives, just as there are accident-prone drivers, who are the last to be employed as trade improves. Among young people, the higher accident rate is probably due to unfamiliarity and lack of training, and maybe some carelessness, and as a rule the accidents are less serious than among adult workers. Here, doubtless, some "safety-first" propaganda could be used effectively. It is at least as important that young people should be as careful in the shops as on the roads.

XUM

Thermal Insulation of O.-H. and Electric Furnaces

Investigations on the more effective thermal insulation of open-hearth and electric furnaces carried out by S. WOHLFAHRT and O. ELL, are described in a recent number of "Jernkontorets Annaler." The authors point out that, as to be expected, the greater reduction in heat losses can be achieved at the hottest parts of the furnace, viz., the hearth and hearth walls, where the refractory brickwork usually offers only a very limited protection against undue heat losses. On colder parts, insulation can also be employed to reduce heat losses, but here it is mainly a question whether the extra costs entailed are commensurable to the saving effected, apart from the practical difficulties in the way of an extensive insulation of the chambers and flues. The effect of additional thermal insulation on the proper operation of the furnace and the quality of the product is also a point which requires consideration, as it may result in increasing the temperature of the flue gases, an increased gas loss, increased lining costs and a higher consumption of refractories. To evaluate the relative importance of these advantages and disadvantages, the authors have carried out a comprehensive series of investigations.

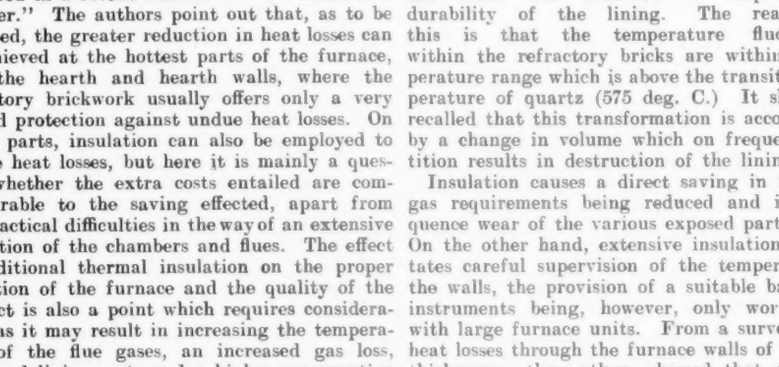

FIG. 1.—THERMAL INSULATION AND HEAT LOSSES.

As regards the insulation of the chamber, it must be remembered that the radiation and conduction losses of the furnace bottom represent on the average 7 per cent. of the fuel consumption, while insulation might, under optimum conditions, be capable of saving 40 per cent. of these losses. By means of a flue-gas economiser 80 per cent. of the heat gained could be recovered, making the overall saving 7 × 0.4 × 0.8 or 2.3 per cent. It is obvious, therefore, that to be worth while, the insulation must be very cheap, and the authors suggest that fine sand alone is suitable. Special attention should also be given to those parts subject to excessive wear from slag, although excessive insulation might result in an increased refractory consumption. The thermal insulation and heat losses for various methods of insulation are shown by the temperature gradient curves in Fig. 1, which give the heat losses per sq. m. of wall surface. Diagrams A and B relate to walls of rammed silica and brickwork, and diagrams C, D and E to various combinations of rammed silica, porous silica, Silocel C 22, natural Silocel and brickwork. It is seen that while the initial and end temperatures on both sides of the walls are practically the same, the temperature gradients are steeper with thinner walls where composite construction is adopted. The view that insulation of the top of the furnace was not possible as it causes an increased wear of the lining and the hearth bottom was found to be untenable. Insulation of the flues was observed to improve the durability of the lining. The reason for this is that the temperature fluctuations within the refractory bricks are within a temperature range which is above the transition temperature of quartz (575 deg. C.) It should be recalled that this transformation is accompanied by a change in volume which on frequent repetition results in destruction of the lining.

Insulation causes a direct saving in fuel, the gas requirements being reduced and in consequence wear of the various exposed parts is less. On the other hand, extensive insulation necessitates careful supervision of the temperature of the walls, the provision of a suitable battery of instruments being, however, only worth while with large furnace units. From a survey of the heat losses through the furnace walls of different thicknesses, the authors showed that a loss of 5,500 kcals. per sq. m. per hr. in a 300-mm. wall is increased to 20,000 kcals. if the thickness is reduced to 75 mm. With a sintered dolomite insulation, the corresponding values were only 2,940 and 4,300 kcals. per sq. m. per hr. It is obvious that reduction in heat losses means additional heat being transmitted to the cold charge, which naturally reduces the melting period and the whole time of reaction in the furnace. This is particularly important as the slag cover always acts as a barrier to heat flow to the bath of metal. At the same time, the temperature gradient from the bath to the hearth bottom becomes diminished, while the mean temperature of the steel, and hence the temperature at tapping, are raised. This does not affect the durability of the furnace bottom, since insulation at the same time increases the sintered depth.

The same considerations naturally also apply to electric furnaces, where a saving is more important owing to the high cost of electric power. In the practical tests carried out by the authors, the hearths were insulated of a 20-ton basic open-hearth furnace, two 19-ton acid Siemens-Martin furnaces, a 3.8-ton basic Rennerfelt electric furnace and a 450-kg. electric furnace of the same type. In the case of the two Siemens-Martin furnaces no numerical data could be obtained of the degree of improvement achieved, as no satisfactory figures were available relating to uninsulated furnaces. But on the whole an increased output of the furnaces and a greater durability of the hearths were observed. The

(*Concluded on page 74.*)

Random Shots

Among the many photographs taken at the Sheffield Conference, some of which have been reproduced in recent issues of the Journal, Mr. W. A. Geisler, of Frankfurt-am-Main, secured what must have been the happiest photograph of the President. "Marksman" reproduces it in this column in the hope that those of his readers who were unable to attend the Conference will realise the quality of Mr. Hurst's infectious smile and the fact that the President of the Institute, at any rate, has evidently no doubts about the prosperity of the foundry industry during the coming year.

* * *

MR. J. E. HURST IN TWO MINDS!
(Snapshot taken at the Sheffield Conference by Mr. W. A. Geisler.)

* * *

The following excellent limerick, sent to "Marksman" by W. E. D., may be puzzling to ignorant Sassenachs. For their sake, "Marksman" points out that by natives of Milngavie, where dwells Bailie Winterton, the new senior Vice-President, that town is pronounced as Mil-guy. Apparently the "n" and the "av" are just thrown in to make things more difficult.

* * *

Said a Bailie, renowned at Milngavie,
"To speak like a Scot I wiln travie,"
So he sang "But an Ben"
And he said "D'ye ken?"
But he couldn't quite manage "och avie."

* * *

Overheard after closing time in the Royal Vic. lounge:—

"Marksman": "What would you most like to see in the FOUNDRY TRADE JOURNAL?"

Hungry Congressist: "Fish and chips."

* * *

Shopping Abroad. Scene: Outside a foundry stores in the South of Belgium. Mrs. "Marksman": "I wonder if they make an iron for which I have been looking for two years. There is a wooden base, a long thin rod and a lump on the end about the size of an egg, and I don't know what they call it in English." *Chef du magasin*: "*Bien sûr, Madame, fer à coq—douze francs.*"

"Marksman" is now searching for the English equivalent of *fer à coq.*

MARKSMAN.

Relationships in Cast-Iron Test Results*

By G. L. HARBACH

Introduction

The suggestion that cast iron is unreliable is to some extent justified when compared with a simple material like steel as, owing to the number of variable factors which operate in the production of iron castings, it is difficult to duplicate results exactly. However, if the extent of the variations can be determined, the resulting knowledge narrows the uncertainty to a known range; confidence on the part of designers is promoted and the large safety factors, generally considered necessary when using cast iron, may be modified.

There are a number of popular ideas regarding cast iron leading to the idea of unreliability which it was felt justified examination first to find if they were true and, if so, to what extent they operated in the mixtures under the author's control. Several investigations have been carried out on these and other points, mainly in the direction of establishing relationships, with a view to finding out the nature of any variables.

The most hopeful investigator of cast iron will admit the work is difficult. The attainment of reliable results under working conditions in any direction, is always liable to be disturbed by the introduction of some unexpected factor, apart from the inevitable variations in the material. It is for this reason that all conclusions are based on the average of all the results available in any one series, the number of tests being quoted in most cases. Furthermore, to reduce variables, all the bars dealt with were cast on end in green sand except the high-test irons which were mainly cast in dry sand. They were made by drawing the pattern out full length, thus avoiding the interference of a joint and providing bars practically true to shape. Unless stated otherwise, the only treatment was lightly grinding on a fettler's grinding wheel in the usual manner.

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Effect of Incorrect Size on Transverse Breaking Load

The most common test applied to cast iron is the transverse test. Being cheap, simple and speedy, it is favoured for routine testing. It may be carried out to give, apart from transverse strength and deflection, valuable information on the properties of toughness, elasticity and resilience as shown by Pearce.[1]

Up to 1928 the standard test-bars were either 2 in. by 1 in. by 36 in. or 1 in. by 1 in. by 12 in. Specifications called for a minimum breaking load and occasionally minimum tensile strengths according to the wishes of the purchaser or inspector. The now familiar three round bars were then adopted and the B.S.I. Specification issued covering two grades of iron with minimum transverse and tensile strengths. Prior to this, the author, whilst experimenting with mixtures for high-duty work, found it necessary to use round test-bars to avoid the chill which invariably occurred in the (then) standard rectangular bars. The size finally selected was 1.655 in. dia. ($1\frac{5}{8}$ in. for practical purposes) broken at a span of 24 in., which should theoretically break at the same loads as the 2 in. by 1 in. by 36 in. bar, thus giving results in terms familiar to all concerned—a point of importance in the foundry where, as a rule, strength was (and often still is) considered in terms of the 2 in. by 1 in. bar.

The $1\frac{5}{8}$ in. dia. bar is still used as it has its scope of usefulness, being almost midway between the M and L bars of the standard specification, but what is likely to be more important, if the E value is included in cast-iron specifications, the span/diameter ratio is practically identical with the S and M bars of the specification and also a suitable tensile bar contains almost the same proportion of the original bar, neither of which can be said of the standard L bar. Table I shows the relative sizes, etc., of the four bars, and it is suggested that when the cast-iron specification[2] be revised the extra bar might be considered as a useful addition to the series.

MR. G. L. HARBACH.

Whilst the foundryman uses the transverse test as a routine test, the engineer as a rule prefers to consider tensile strength as a basis for design. If a ratio between transverse and tensile strength can be established, it would enable both foundrymen and engineers cheaply and readily to obtain the results most suitable for their respective purposes. Such a relationship requires that both properties be in the same terms—generally tons per sq. in. This is usual for tensile, but the breaking load in transverse requires converting to modulus of rupture by a formula, which takes into consideration the shape, size and span of the test-bar. For this purpose, it is essential that the bar be measured accurately, as the slight, but inevitable, variations in size, even when using the same pattern, will cause comparatively wide differences in breaking load. When the 2-in. by 1-in. bar was used, it was usual to allow 1 cwt. per $\frac{1}{32}$ in., which was fairly close for small differences when the breaking load was from 30 to 35 cwts. Using the M bars for Grade A iron, 0.025 in. will affect the breaking load about 100 lbs., or 1.2 tons modulus of rupture (5 per cent. error), and with an iron of 16 tons tensile about 160 lbs., or 1.8 tons (6 per cent. error), so that for routine testing, when using the same size of bar for comparing different mixtures, the corrected breaking load is necessary, and the modulus of rupture must be determined to compare the results of bars of different shapes. The B.C.I.R.A. recommendation (see Pearce[1]) that modulus of rupture be used for reporting transverse strength is strongly supported, and this method is used by the author.

It is an advantage to have a chart with the correction factors for most of the variations of standard bars, and this is given in Table II, together with the formula and factors for calculating the modulus of rupture. Columns 2, 5 and 8 give the factors for calculating breaking load to correct size, and columns 3, 6 and 9 the factors for calculating modulus of rupture direct from the breaking load of bars of incorrect sizes.

Relation Between Transverse and Tensile Strengths

Figs. 1 to 4 show transverse and tensile results of 2 in. by 1 in., and three round bars from ordinary foundry mixtures (the results of L bars being too few to be representative have been omitted), and the ratio curves obtained by dividing the transverse by the tensile strength for each sample and taking the mean in groups of each ton of tensile strength. Figs. 5 and 6 give the same information regarding high-test cast irons, one the low-carbon type (2.6 to 2.8 per cent. T.C.) without alloys, and the other a medium-carbon (2.9 to 3.1 T.C.) type containing $1\frac{1}{2}$ per cent. nickel.

TABLE I.—*Typical Breaking Loads and Relative Sizes, etc., of Three Standard Test-Bars with Extra W.S. and 2-in. by 1-in. Bars for Comparison.*

	TRANSVERSE				TENSILE		
BAR	DIAM INS	SPAN INS	SPAN DIAM	TYPICAL BREAKING LOADS LBS	DIAM INS	AREA SQ INS	PROPORTION OF ORIGINAL BAR %
S	0.875	12	13.7	1360	0.564	.25	41.7
M	1.2	18	15.0	2310	0.796	.5	44.4
L	2.2	18	8.2	11,770	1.785	2.5	86.0
W-S	1.655	24	14.5	4020	1.13	1.0	46.7
2"x1"	–	36	–	3670	–	–	

Examination of Figs. 2, 3 and 4 shows that there is little difference between the ratios of the three bars for the results under review, although calculations made from the Institute of British Foundrymen's Sub-Committee's Report[4] clearly showed a marked difference in ratios between the S, M and L bars over tensile ranges of 11 to 18 tons. These were very close to 1.9 throughout for the L bar; from 2.4 to 2 for the M bar—much higher than shown in Fig. 3—and from 1.8 to 1.5 for the S bar which is rather lower than is shown in Fig. 2. Consideration of these differences supports the view that irons produced under uniform conditions are less affected in their properties by variations in section size than irons produced under varying conditions when it is remembered that the Institute's experiments were carried out on 40 different irons with deliberate variations of analysis.

It will be seen that the trend in every case is for the ratio to fall as the strength increases. In other words, tensile strength increases proportionally more rapidly than transverse strength. In the 2-in. by 1-in. bars the ratios fall between 2 and 1.5, with a fairly close average around 1.8 to 1.7 except for the 7.2 tons tensile sample, which is included to show the type of relationship existing in the low-strength irons. Further, in connection with 2-in. by 1-in. bars, 12 results from bars cast under different conditions, having a tensile range of 11 to 14 tons, gave ratios of 1.7 to 1.4, the average being 1.67 to 1.5. These results are mentioned as being similar to those occasionally used for calculating, but are definitely below the results shown in Fig. 1, and still more below the results from round bars, a case in point being the standard formula for piston-ring tests (1.6).

* A Paper read before the Annual Meeting of the Institute of British Foundrymen at Sheffield, July 2 to 5, 1935.

If the ratio curves be examined without considering the results from which they were compiled, they indicate closer relationships than actually occur in practice, and each has been included in the same figure to permit easy comparison of the variations above and below the mean. The fact that all are taken from commercial results obtained from different cupolas, various mixtures, etc., without discrimination, increases the width of variation as compared with a few results prepared under carefully controlled conditions, but from a practical point of view this should be more advantageous than otherwise. In the majority of cases a range of 1 ton tensile is associated with a range of 2 to 4 tons transverse and a range of 1 ton transverse with a range of 2 to 3 tons tensile, thus calculations from the mean ratios can only be accepted within ±8 per cent. when taking the curves as a whole. Experience has shown, however, that for a constant mixture the limits for tensile may be considerably reduced. As an instance the group of nine results from the S bar ranging between 17.3 and 18.3 tons tensile and 30.5 to 34.2 tons transverse were all from the same mixture taken over a period of several months. The limits about the mean being ±3 per cent. in tensile and ±6 per cent. in transverse suggests that under standardised conditions the tensile is less variable than the transverse. Such a result is not unexpected as it is well known that slight defects in the surface of a transverse bar on the tension side may cause a considerable drop in breaking load, although the fracture may appear sound—a loss of strength which does not occur in the tensile bar as it is invariably machined. The effect of different surface finishes on the transverse result will be dealt with later, but at present it will be well to note the higher average strength of the machined bars.

TABLE II.—*Factors to Calculate Transverse Breaking Load at Correct Size and Modulus of Rupture, from the Breaking Load of Bars of Various Diameters.*

$$\text{Corrected breaking load} = \frac{\text{actual breaking load} \times \text{standard diameter}^3}{\text{actual diameter}^3}$$

$$\text{Modulus of rupture in tons per sq. in.} = \frac{\text{Load in lbs.} \times \text{span in in.}}{4 \times \text{dia.}^3 \times 0.0982 \times 2240}$$

S BAR			M BAR			L BAR		
DIAM.	BREAKING LOAD TO LOAD AT ·875" D.	BREAKING LOAD TO MODULUS OF RUPTURE	DIAM.	BREAKING LOAD TO LOAD AT 1·2" D.	BREAKING LOAD TO MODULUS OF RUPTURE	DIAM.	BREAKING LOAD TO LOAD AT 2·0" D.	BREAKING LOAD TO MODULUS OF RUPTURE
·77	1·469	·02990	1·10	1·298	·01521	2·10	1·150	·002210
·78	1·413	·02878	1·11	1·264	·01491	2·11	1·134	·002180
·79	1·358	·02765	1·12	1·230	·01462	2·12	1·117	·002150
·80	1·308	·02663	1·13	1·198	·01413	2·13	1·103	·002115
·81	1·261	·02568	1·14	1·166	·01370	2·14	1·087	·002090
·82	1·216	·02477	1·15	1·136	·01341	2·15	1·071	·002060
·83	1·172	·02386	1·16	1·107	·01307	2·16	1·056	·002030
·84	1·130	·02300	1·17	1·079	·01274	2·17	1·041	·002000
·85	1·091	·02220	1·18	1·052	·01242	2·18	1·027	·001975
·86	1·053	·02143	1·19	1·025	·01210	2·19	1·014	·001945
·87	1·018	·02072	1·20	1·000	·01180	2·20	1·000	·001922
·875	1·000	·02036	1·21	·976	·01151	2·21	·987	·001895
·88	·984	·02005	1·22	·952	·01124	2·22	·974	·001870
·89	·951	·01935	1·23	·930	·01096	2·23	·961	·001845
·90	·920	·01871	1·24	·906	·01069	2·24	·947	·001818
·91	·889	·01809	1·25	·884	·01043	2·25	·935	·001795
·92	·861	·01751	1·26	·864	·01019	2·26	·924	·001773
·93	·834	·01696	1·27	·845	·00997	2·27	·912	·001750
·94	·808	·01643	1·28	·826	·00978	2·28	·900	·001727
·95	·782	·01592	1·29	·806	·00950	2·29	·888	·001703
·96	·758	·01541	1·30	·787	·00928	2·30	·876	·001681
·97	·734	·01494						

EXAMPLE:— BREAKING LOAD OF 2570 LBS. WITH 1·22" DIAM.
2570 × ·952 = 2445 LBS. ON 1·2" DIAM.
2445 × ·0118 = 28·9 TONS PER SQ. IN. MODULUS OF RUPTURE.
OR 2570 × ·01124 = 28·9 " " " " " "

In the low-carbon iron (Fig. 5) the results and ratios are scattered more widely than those of the irons of lower strength. In the tensile range 21 to 22 tons the transverse varies from 32 to 42 tons (ratios 2 : 1 to 1.5 : 1) for the as-cast bars, and although the machined bars are in the main more consistent (ratios 2.2 : 1 to 1.9 : 1) —and show more marked increases in transverse strength than machined bars of lower-strength irons—two machined bars (21.8 and 24.2 tons tensile) are well below the mean of the series. This suggests that for this class of iron machined bars are to be recommended if reliable transverse results are to be obtained, although factors causing high tensile strength may not necessarily raise the transverse to the same degree, even when machined bars are used, as shown by the two bars mentioned. Incidentally, the A.S.T.M. specification for two irons with minimum tensile strength of 22.3 and 26.8 tons show ratios of 1.48 and 1.37 respectively for the 1.2-in. dia. bar which appears to be a generous allowance for low transverse results in this class of iron, although for the 0.875 in. and 2 in. dia. bars the ratios for the same tensiles are 1.55 and 1.58, and 1.68 and 1.65 respectively.

TABLE III.—*Effect of Machining Transverse Bars.*

Nº OF BARS	DIAM. INS. CAST	DIAM. INS. MACHINED	TENSILE TONS ①	MODULUS OF RUPTURE TONS ② AS CAST	MODULUS OF RUPTURE TONS ② MACHINED	GAIN % MEAN	GAIN % HIGH	GAIN % LOW
5	0·88	0·8	15·1	28·3	30·9	9	18	4
1	0·88	0·8	20 APPROX	28·4	36·1	27	-	-
3	1·2	1·1	14·7	29·1	28·8	10·5	11	10
5	1·2	1·1	21·1	34·4	40·2	17	28	9
3	1·2	0·9 ·	14·7	29·1	29·5	13	20	7
1	1·65	1·6	17 APPROX	24·1	29·3	21	-	-
3	1·65	1·5	14 "	23·6	28·2	19	30	16
5	1·65	1·3	14 "	23·6	28·3	20	31	13
1·	1·65	1·5	18 "	28·6	35·8	25	-	-
1	1·65	1·4	18	29·8	36·6	23	-	-
1	1·65	1·3	18 "	28·6	34·3	20	-	-
2	1·65	1·2	18	30·0	35·8	19	18	21
1	1·65	1·0	18 "	30·1	32·8	9	-	-

SPANS USED IN ABOVE TESTS

DIAM.	AS CAST	MACHINED
0·88"	12"	12"
1·2"	18"	12"
1·65"	24"	12"

Fig. 6 shows 1½ per cent. nickel irons intended to meet a specification of 18 to 20 tons tensile of the 1.2 in. dia. bars with the exception of the 23 to 24 ton results which were from an experiment to produce a 25-ton iron by inoculation. Compared with Fig. 5 the lower tensile strength gives the impression of better grouping and greater consistency which may not be quite justified, but on the practical side there is no doubt that when high strength is a primary consideration the inclusion of 1½ per cent. nickel not only produces more consistent results but, by permitting a higher total carbon, considerably improves the castability, and on this account may more than offset the increase in metal cost by reduced scrap castings.

Dealing with Figs. 5 and 6 together, the mean ratios commence roughly where the lower strength irons left off—1.8 at 16 tons—falling to

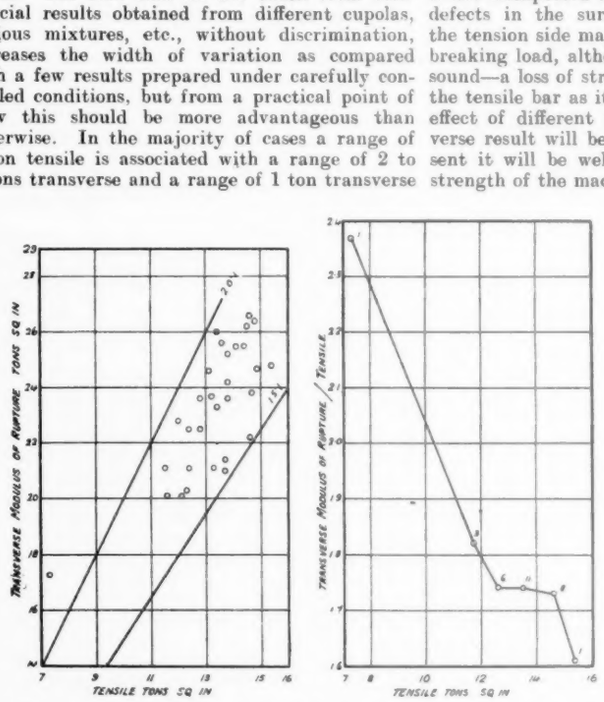


FIG. 1.—TRANSVERSE, TENSILE RESULTS AND RATIOS, 2-IN. × 1-IN. BARS.

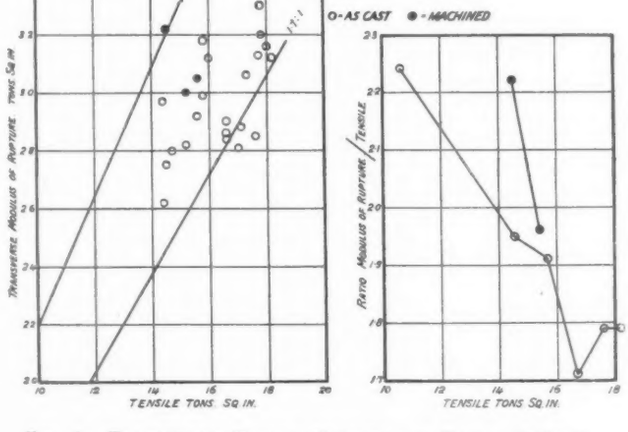

O-AS CAST ● - MACHINED
TRANSVERSE MODULUS OF RUPTURE TONS SQ IN
TENSILE TONS SQ IN.
RATIO MODULUS OF RUPTURE / TENSILE
TENSILE TONS SQ IN.

FIG. 2.—TRANSVERSE, TENSILE RESULTS AND RATIOS, 0.875-IN. DIA. BARS.

1.6 for 20 to 28 tons, which is quite close to the A.S.T.M. ratios for the 0.785-in. and 2-in. dia. bars previously mentioned. In this respect it is worthy of remark that the Institute's results, the A.S.T.M. specification and the author's results for the largest bar all vary over a narrower range of ratios than either of the other two bars.

Fig. 7 gives the combined ratio curves from

On the whole, it is felt that for irons in which strength is an important feature the transverse test is a useful guide for routine tests, but for all other purposes the determination of tensile strength is preferable to estimation from transverse strength, particularly as engineers think of strength in terms of tensile, and therefore by this method will more readily appreciate the improved properties of cast iron and the high

treatment (*a*) or (*c*). The following summarises the results obtained in tons per square inch modulus of rupture:—

Mean of 12 bars treated normally (*b*)	23.6
Mean of 12 bars with skin untouched (*a*)	22.8
Mean loss by no grinding	0.8
Highest loss by no grinding ...	2.4
Lowest loss by no grinding (gained)	0.7

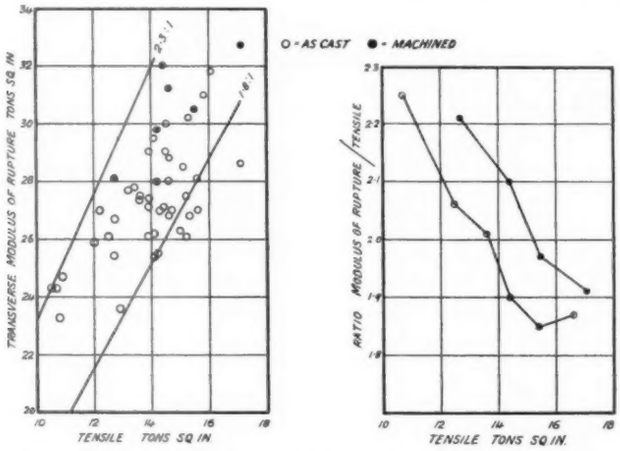

O - AS CAST ● - MACHINED
TRANSVERSE MODULUS OF RUPTURE TONS SQ IN
TENSILE TONS SQ IN
RATIO MODULUS OF RUPTURE / TENSILE
TENSILE TONS SQ IN

FIG. 3.—TRANSVERSE, TENSILE RESULTS AND RATIOS, 1.2-IN. DIA. BARS.

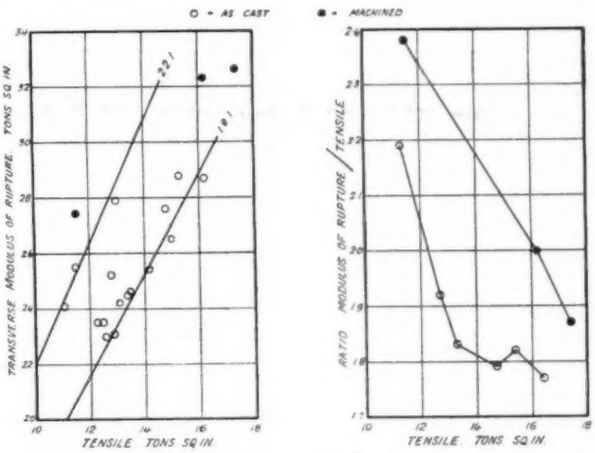

O - AS CAST ● - MACHINED
TRANSVERSE MODULUS OF RUPTURE TONS SQ IN
TENSILE TONS SQ IN
RATIO MODULUS OF RUPTURE / TENSILE
TENSILE TONS SQ IN

FIG. 4.—TRANSVERSE, TENSILE RESULTS AND RATIOS, 1.65-IN. DIA. BARS.

Figs. 2 to 6, from which it may be noted that the ratio of 2 to 1.8 for 13 to 17 tons tensile confirm the results of Pearce[5], and, on the whole, follow similar lines to the five curves quoted by MacKenzie,[6] except for the sharp fall from 1.6 to 1.1 for strengths of 17 to 26 tons. Whilst in the irons below 18 tons tensile the transverse strength may be considered as having a fairly close relationship, it is obvious that, with the stronger irons, the relationship varies more widely, even with machined transverse bars, so that tensile tests are necessary if the actual strength is to be determined.

Summarising the conclusions regarding transverse and tensile relationship: The ratio falls with increasing strength from 2.3 at 10 tons tensile to 1.6 or less at over 20 tons tensile, but is not constant for any particular range of strength within closer limits than ± 8 per cent., except when produced under closely-controlled conditions, when, from a mixture of pre-determined strength, a normal transverse result will generally indicate a normal tensile strength. Machined transverse bars are higher in strength than bars tested "as-cast," thus giving higher ratios—a difference which increases with increasing strength.

strengths now available. Moreover, tensile will probably prove the more suitable means of classification when the high-strength irons are included in a standard specification.

Effect of Surface Condition on the Transverse Result

It is well known that the breaking load of a test-piece is affected by the surface finish, but against this, so far as cast iron is concerned, it is popularly believed that the skin is the strongest part of a bar, although usually in such a case the surface is bound to be rough. Transverse tests were carried out to find the difference between bars:—

(*a*) As removed from the mould and adhering sand removed by a wire brush.

(*b*) Fettled in the normal manner by lightly grinding so that all sand and roughness were removed, but in the main with the skin left intact.

(*c*) By grinding more than usual to remove the skin entirely (actually 0.01 to 0.02 in.).

(*d*) By machining to various depths.

With the exception of the machined bars, pairs of bars were cast in each case, one being treated normally (*b*) and the other having the special

Apart from the highest and lowest differences, the losses consistently varied between 0.3 and 1 ton, so that if the high and low were discarded as being due to other causes, the mean would still remain the same.

Mean of 8 bars treated normally (*b*)	26.8
Mean of 8 bars skin ground (*c*) ...	26.05
Mean loss by skin grinding ...	0.75
Highest loss by skin grinding ...	1.3
Lowest loss by skin grinding ...	0.3

Owing to the consistency of these results, eight bars were considered as sufficient to prove the point.

The mean differences, which amount to about 3 per cent. in each case, are no more than might be expected between any pair of bars, but the trend is sufficiently marked as to be definitely against either no grinding or severe grinding, although in the latter case, if the grinding wheel was wearing smooth, something approaching a machined finish might be obtained to the advantage of the bar. Table III gives the results of different sizes of bars from high- and medium-strength mixtures tested "as-cast" (normal fettling), and after machining to various diameters. The S bars were from duplicates, one as-cast and one machined; the M bars were from top and bottom halves of 26-in. bars machined and tested at 12 in., previously tested "as-

(*Continued on page 72.*)

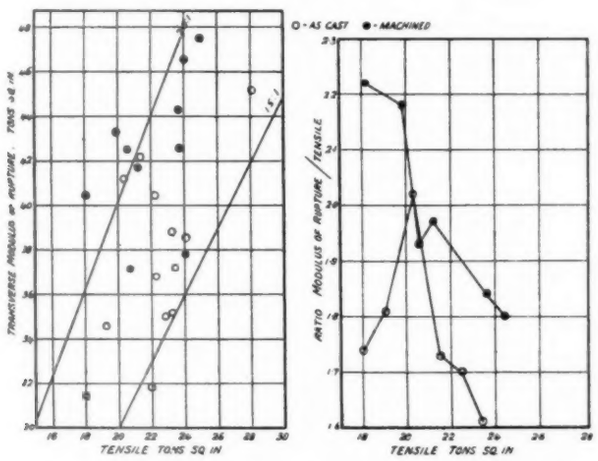

O - AS CAST ● - MACHINED
TRANSVERSE MODULUS OF RUPTURE TONS SQ IN
TENSILE TONS SQ IN
RATIO MODULUS OF RUPTURE / TENSILE
TENSILE TONS SQ IN

FIG. 5.—TRANSVERSE, TENSILE RESULTS AND RATIOS, HIGH-TEST CAST IRON (LOW CARBON), 1.2-IN. DIA. BARS.

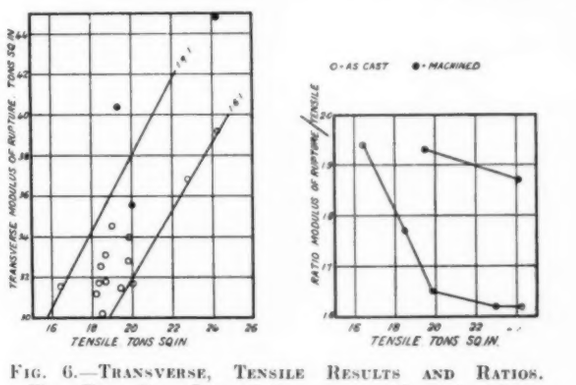

O - AS CAST ● - MACHINED
TRANSVERSE MODULUS OF RUPTURE TONS SQ IN
TENSILE TONS SQ IN
RATIO MODULUS OF RUPTURE / TENSILE
TENSILE TONS SQ IN

FIG. 6.—TRANSVERSE, TENSILE RESULTS AND RATIOS. HIGH-TEST CAST IRON (1.5 PER CENT. NICKEL), 1.2-IN. DIA. AND 1.65-IN. DIA. BARS.

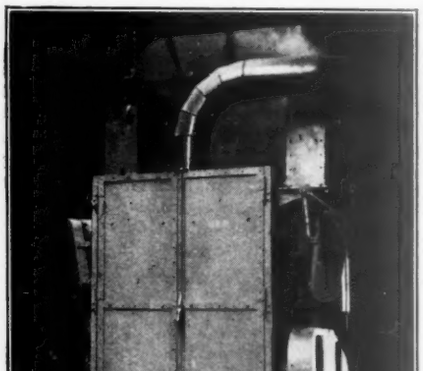
The Sand Wizard

A NEW TYPE OF SHOT BLAST CLEANING MACHINE

In recent years engineers have been devoting increased attention to the fettling shop in general, and to its equipment in particular. Prominent amongst machines which have undergone radical changes in the last decade is the sand-blast machine. Most of these changes, however, were in the direction of steady and straight-line developments, but the Sand Wizard is of a type which breaks entirely new ground. The one inspected by our representative is installed in the vitreous-enamelling department of the Parkinson Stove Company, Limited, at Stechford, Birmingham, where it has been installed by the Constructional Engineering Company, Limited, of Titan Works, Charles Henry Street, Birmingham. At the time of writing the machine had been running a month, and beyond very minor teething troubles has given complete satisfaction, though it has been operating night and day.

Details of Machine

The fundamental difference between the Wizard and an ordinary sand or shot-blast outfit is that the jet of sand is projected by centrifugal force instead of by compressed air. This particular model enters the field as a tumbling barrel, the actual perforated barrel being 40 in. long by 40 in. in diameter. This barrel, which will carry about 10 cwts. of castings, rotates slowly, whilst the contents are subjected to a double stream of No. 18 chilled iron grit. This grit falls through the perforations of the barrel casing and passes through the grid floor of the cabinet which encloses the entire barrel into a pit. At the back of this pit are bucket elevators which return the grit—there is about 6 cwts. in the system—to two hoppers which are above the projector heads. These heads, which are rotated at a speed of 2,850 revs. per min., eject the shot at a rate of 9,000 ft. per min. The dust removed from the surface of the castings is drawn through the roof of the casing to enter the general dust-extraction system of the works.



THE "WIZARD" AIRLESS CASTINGS CLEANING MACHINE.

INTERIOR VIEW OF THE "WIZARD."

Power Requirements

It is claimed for the Wizard that it is extremely economical in power as compared with the normal compressed-air-operated machines. Figures as high as 90 per cent. are mentioned. Following the good old-fashioned rule of having plenty of reserve, 9 h.p. has been installed, but actually just under 5.4 h.p. is being used, as against 35 h.p. for a compressed-air machine of equal capacity, which will also have a matter of five or six more for various drives.

Renewals and Working Speeds

Like ordinary sand-blast nozzles, the projector blades or vanes are subject to wear. When made of special alloy steel they last about 30 hrs., but like the nozzles they can in emergency be replaced by castings made in the user-foundry. Bulk rather than weight is the determining factor in the efficiency of surface-cleaning machines, and at the Stechford Works 5 cwts. of stove-grate castings have been adequately prepared for vitreous enamelling in the new machine in twelve minutes. Our representative was informed that this first month's experience has convinced the enamelling shop of the superiority of the surface yielded by the new system. Freedom from dustiness has been notable. The machine is relatively noiseless in operation—an increasingly important factor in industrial machines. This machine being the pioneer installation in Britain, many types of castings have already been handled, and *inter alia* 7½ cwts. of steel castings are quoted as having been very thoroughly cleaned in eight minutes, whilst 9 cwts. of cored malleable castings took nine minutes. If the machine can establish considerable savings in time, then the 90 per cent. reduction in power consumption, claimed when related to weight or better surface area, is well on the way to achievement.

Other Costs

It appears from these early experiments that the machine is "kind" to the grit, and the whole consignment is not replaced, but as it breaks down, one or two bagfuls are added. Naturally, the type of grit used will vary with the nature of the work to be undertaken. Loading and unloading are temporarily accomplished by hand from and to truck, but this remark applies to the model being described. The "Wizard" can, of course, be attached to a rotary table or any other mechanically-operated plant. The question of dust extraction is a problem exactly analogous to compressed-air-operated machines. It appears from the trade literature dealing with the "Wizard" that quite a number of models are available. The one we have described is the 40 in. by 40 in. size and it occupies an area about 5 ft. 6 in. square, whilst the height is of the order of 11 ft. 6 in. In conclusion, we wish very sincerely to thank Mr. R. J. Rogers, managing director of the Parkinson Stove Company, for the courtesies he and his colleagues extended to our representative, and to Mr. D. H. Wood, Managing Director of the Constructional Engineering Company, Limited, for the loan of photographs.

Book Review

Principles of Phase Diagrams. By J. S. Marsh, with a foreword by John Johnston. Published by the McGraw-Hill Publishing Company, Limited, Aldwych House, London, W.C.2. Price 18s. net.

The latest addition to the Alloys of Iron Monographs published for The Engineering Foundation by McGraw-Hill is devoted to the principles of phase diagrams. The contributions to this series already issued, dealing respectively with alloys of iron and molybdenum, silicon, tungsten and copper, have been very well received in this country, and their reception is thoroughly justified. Metallurgists look forward eagerly to the issue of further volumes, of which five are announced as being in preparation.

The volume under review is very welcome indeed; the object is stated succinctly in the foreword, which the reviewer cannot do better than repeat.

"The thermodynamic principles which enable us to describe most clearly the whole behaviour of a system under changing conditions of temperature, composition, and pressure are simple; to apply them correctly, even to seemingly simple systems, may however be difficult and complex. The aim of this book is to set forth, as simply as may be, yet rigorously and briefly, how these principles serve to interpret correctly, and to correlate, the many, seemingly quite different, cases which actually arise, even in systems of not more than three components. The reason for it is to obviate the necessity of discussing questions of interpretation of phase diagrams and diagrams of state in each of the monographs."

In point of fact, the book does more than this, and beyond dealing with the principles of phase diagrams, includes a very useful selection of actual diagrams used to illustrate the meaning of the principles. The book is readable—often absorbing—and will be a boon to the metallurgist seeking a clear and helpful guide to the modern interpretation of the work initiated by Gibbs in 1875. We can think of no better expression than to say that this volume is a very worthy addition to this splendid series of monographs, and that we cannot imagine how any one interested in metallurgy can fail to find it both interesting and fascinating reading and a constant help as a book of reference. We wholeheartedly commend it to our readers.

T. S.

MESSRS. WILLIAM JACKS & COMPANY, Winchester House, Old Broad Street, London, E.C.2, inform us that their telephone number has been changed to London Wall 4774 (5 lines).

MR. F. MELMOTH, steelworks manager of the Detroit Steel Castings Company, Detroit, U.S.A., is arriving in Liverpool on August 9. He intends to spend a few weeks in England.

A Note on the Influence of Temperature Gradients in the Production of Steel Castings*

By GEORGE A. BATTY

[AMERICAN EXCHANGE PAPER.]

In the production of steel castings in sand moulds, or in moulds formed of other refractory materials, a great deal of attention has been given to the provision of feeding heads of adequate size and proper location to promote soundness—freedom from that mid-section cavity known as enclosed pipe—in all parts of the piece. As the complexity of the design increases, and as sharply differential sections are conjoined or relatively heavy masses imposed on a generally lighter structure in positions which are difficult to reach with feed metal, the difficulty in promoting soundness throughout the complete structure generally increases.

The casting of complex design presents additional difficulties, which increase the liability to failure, the resistance of the mould to the normal contraction of the solidified metal introducing the tendency to hot tearing or cracking. Despite this fact, it is a common foundry experience to find that among the castings most difficult to produce of a grade that is both commercially satisfactory and free from serious metallurgical deficiencies are pieces which are of harmonious or simple design, such as hammer blocks and gear blanks.

In part this is due to the relation of area to mass and in part to the system of gating and heading employed. The relation of surface area to mass of cast metal is briefly but illuminatingly commented upon by Briggs and Gezelius[1] who made a series of four pairs of castings—each pair being a sphere and a parallelepiped—and determined the rate of skin-formation or actual solidification by turning over the mould after a predetermined time interval, and pouring out through the gate the metal which remained liquid.

The sphere and the rectangular block were of identical volume, but the parallelepiped was of 50 per cent. greater surface area than the sphere. The rate of skin formation was found to be almost identical for both sphere and block, but the point of greatest significance to the practical foundryman is that, in the same time intervals, approximately 50 per cent. more metal solidified in the mould producing the parallelepiped than in that producing the sphere.

This set of experiments illustrates quite strikingly what may be defined as "rate of feed demand," which is important to the founder in determining the size and shape of the feeding head to be imposed to promote the internal soundness of the casting. The shape or design of a casting must, therefore, have some considerable bearing upon the ultimate cost by reason of the amount of metal necessary to produce the piece and the concomitant cost of cleaning off the discard.

It is not necessarily to be assumed that the rate of solidification of the parallelepiped will continue to be 50 per cent. greater than that of the sphere, but the reported results of the series of tests show strikingly that the distance of the centre of the mass from the two nearest opposed mould faces has a profound effect upon the rate of solidification—expressed as a progressive proportion of the weight, not as linear thickness of the continuously-thickening solidified envelope—and, therefore, upon the rate of demand for metal from the superimposed feed head.

In the case of the sphere the centre of the mass of the casting proper is equidistant from every part of the mould-metal interface, which, giving the lowest possible ratio of surface-area to mass, predicates the slowest rate of feed demand and, in practice, the greatest amount of metal to be imposed as a feed head to promote soundness of the cast structure. Briggs and Gezelius did not state the dimensions of the rectangular piece used in their experiments for comparison with the sphere, but what they demonstrated in their comparison may also be applied to a consideration of rectangular shapes of different ratios of surface area to mass.

MR. GEORGE A. BATTY.

Within fairly well defined limits—prescribed by the "castability" of the metal—it is easier to produce commercially satisfactory castings, in relation to internal soundness, as the ratio of surface-area to mass increases.

The massive casting, say a hammer block, is more difficult to produce free from shrinkage cavity, and is more expensive in the amount of metal required, plus the cost of cleaning or fettling, than is a piece of similar weight, say a simple baseplate, having a much larger ratio of surface area to mass.

The foregoing discussion has had relation to castings produced by what may be considered orthodox steel foundry practice in relation to gating, heading, and pouring procedure—gating into the base of the mould cavity; either filling the mould completely, including the feeding head, through the downgate, or filling the mould proper through the downgate and then filling up the head by pouring directly into it; by using metal as cool as possible, and by filling the mould as quickly as possible. Under such governing conditions it is not possible, even on the simplest forms of castings, to have any pronouncedly favourable temperature gradient in the metal at the moment the mould is filled, and, by reason of the gating employed, the mould will have acquired an adverse temperature gradient related in degree to the pouring rate and to the section thickness of the casting.

Section Thickness and Pouring Rate

Section thickness must be considered in relation to pouring rate (rise of metal in mould per second), and it is common foundry practice to ensure a high-pouring rate for light sections—a cylinder cast vertically, as instance. Despite this fact, there is likely to be produced in both mould and casting a distinctly adverse temperature gradient which is inimical to the ultimate integral soundness of the cast structure. The observed fact that the metal which appears in the risers and vents of a bottom-poured casting is very much cooler than the metal delivered to the downgate is such a foundry commonplace, so thoroughly in accord with what is to be expected, that its tremendous significance has not been properly appreciated.

The obviously adverse temperature gradient in the metal has been noted and feeding heads provided of such shape and capacity as to show sound metal when they were cut off and the casting dressed down to the proper size. If the feeding heads have to be relatively large in order to promote such apparent soundness and if they are filled through the casting—as distinct from being filled individually from the open top—they may help to promote unsoundness in the lower levels of the casting by causing more metal to be passed through the mould, whereby the adverse temperature gradient is increased in both mould and metal.

A Concrete Example

So far as the feeding heads themselves are concerned, they, being necessarily of considerably heavier section thickness than the part of the casting upon which they are imposed, become reservoirs of heat in proportion as they are reservoirs of metal, and so produce, strictly locally, a favourable temperature gradient. Hence, the apparent soundness of the casting immediately below such feeding heads. To indicate the relevance of temperature gradients a type of casting has been chosen for discussion which had given some considerable trouble by reason of defects which, while being repairable, were of considerable commercial significance. The casting is fairly simple, is of harmonious design and of almost uniform section thickness. The deficiencies in the casting were all in the lower levels, leaks at the fillets or radiused junction of flange with body, and at bolt-holes on the bottom flange.

The orthodox method of heading and gating which was used for the casting under discussion is illustrated on Fig. 1. The mould was placed in a horizontal position on the pouring floor and the casting was poured "flat." It should be noted that the upper ingate D is not a true "step-gate" and cannot exercise the devised function of promoting the selective flow of metal from the downgate into the upper levels of the casting. Without a "breaker-gate," devised to check the downward velocity of the cast metal, such an ingate as D cannot reasonably be expected to function properly.

To overcome the deficiencies apparent in the castings made on the orthodox method, such deficiencies being attributable to the adverse temperature gradients in both mould and metal, and to the local "hot spots" at the lower ingates, promoting the formation of both external tears and mid-section cavity, the "partial reversal" method was used as described in other Papers by the author.[2] The method is indicated in Fig. 2, whereon the casting is shown in the pouring position, the mould being "banked" on a reversing block to an angle of 150 deg., the block being of such a height or thickness as will permit of "reversing" the mould through an angle of 30 deg., after pouring is completed, to produce an "angle of rest" of about 15 deg.

* A Paper read before the Annual Meeting of the Institute of British Foundrymen at Sheffield, July 2 to 5, 1935.

1 Briggs and Gezelius. "Studies on Solidification and Contraction and their Relation to the Formation of Hot Tears in Steel Castings." "Proc. American Foundrymen's Association," 1933.

2 Batty, Geo. "Controlled Directional Solidification." "Journal of the American Society of Naval Engineers," February, 1934, and August, 1934. "Controlled Directional Solidification." "Trans. American Foundrymen's Association," 1934.

As the gating and heading system, illustrated on Fig. 2, may be somewhat difficult to understand, an additional explanatory diagram is provided in Fig. 3. The vent F is taken from the crown of the blind feed head E to the mould joint and the vents H, H, H, are taken from the mould cavity at locations which are the high plane of the casting proper, in the pouring position.

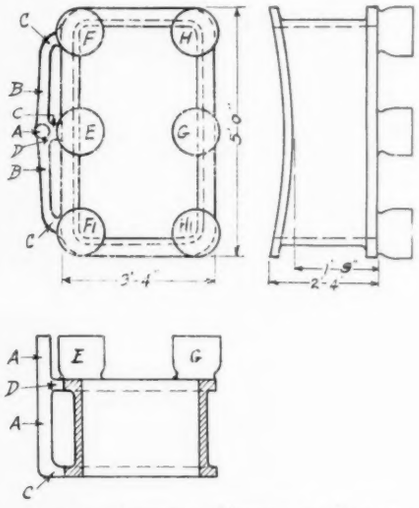


FIG. 1.—ORTHODOX METHOD OF GATING A TROUBLESOME CASTING.

A = Downgate. B, B = Crossgates. C, C, C = Ingates to lower flange. D = Single ingate to upper flange. E, F, F1, G, H, H1 = Feed heads.

tion. It is essential that these latter vents be adequate to permit the egress of the atmosphere of the mould cavity at such a rate as will avoid developing any serious back pressure, which would oppose the inflowing metal; but, in ensuring such adequacy of aperture, it is necessary to avoid a shape of section which may promote a defect in the casting.

Rectangular Vents Advocated

Experience has shown that round vents, of sufficient diameter to evacuate the mould atmosphere at a proper rate, will frequently reveal an unsound spot—a fine pipe—in the casting

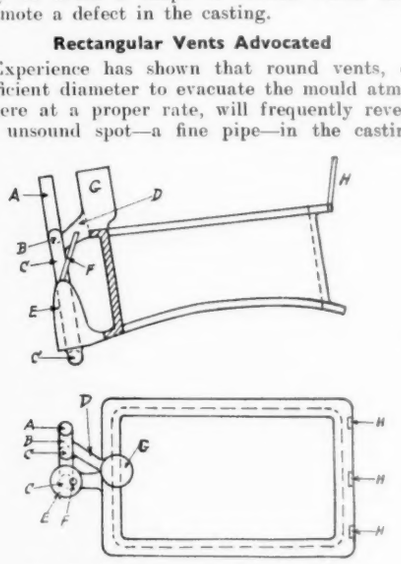


FIG. 2.—SUGGESTED IMPROVED METHOD OF GATING, WHERE—

A = Primary downgate. B = Crossgate or breaker-gate. C = Lower downgate—horn-gate type produced as half-cores. D = Step-gate—slot-gate type. F = Vent from E to mould joint. G = Upper feed head. H, H, H = Vents from high-level mould cavity in pouring position.

when removed. Vents of rectangular section are greatly to be preferred, and the thickness of such vents should not be greater than one-half the thickness of the section upon which they are imposed. The thickness of the vents being prescribed by the casting, their width has to be determined in relation to the devised pouring rate to ensure that serious back pressure by mould atmosphere is not generated during pouring. Vent F is small, and may be of circular cross-section.

A comparison of the two methods of producing the casting, illustrated on Figs. 1 and 2, may best be made if one considers vertical sections of the casting, one for each method, comprising gate and head as well as casting. The casting as produced on the orthodox method is shown on Fig. 4.

Notwithstanding the provision of the step-gate C, it is affirmed that the casting, as shown on Fig. 4, would be almost entirely bottom-poured, provided that metal temperature and pouring rate were such as to run the casting cleanly, without the formation of serious "cold shuts" or deeply penetrant ripples. In actual practice, metal was delivered at the downgate until a level was attained approximating the line X-X on Fig. 4. Pouring at the downgate ceased and feed metal delivered to the head by top-pouring directly into the feeder. (Reverting to Fig. 1, and continuing to describe actual practice, it should be stated that riser G was the first to be top-filled, pouring continuing until either the head was filled, or, if metal was flowing to the other risers, until a quantity had been delivered to G approximately equal to twice its capacity. Thereafter, metal was added, in turn, to each riser or feed head until all were filled. As a general rule, however, the metal was so cool at G, H, and H1, that G could be completely top-filled without promoting any rise of metal-level in the other feed heads.)

Most British foundrymen are likely to be acquainted with Brearley's graphic representation of the freezing of an ingot, inscribed lines approximately parallel to the mould faces being used to indicate the progress of the formation of the continuously-thickening solid envelope. The casting under discussion (Fig. 4) might be considered as a very poorly-designed ingot, parallel sided, and much too great in length—height, as poured—in relation to its diameter or section thickness. Added to this, there are the disadvantages to be associated with bottom pouring. This system of gating could not very well be entirely avoided, as the castings were necessarily produced in green-sand moulds.

Influence of Bottom-Gating

The bottom-gating of a casting inevitably produces an adverse temperature gradient in the metal, the top of the casting being coolest and the bottom being hottest at the moment the mould proper is filled. The amount of this temperature difference, and the "angle" of the temperature gradient, are related to the pouring rate—rise of metal in mould per second—and to the heat-conductivity of the mould. A slow pouring-rate will produce a poor temperature gradient, as compared with that produced by fast pouring, when the gradient is indicated in the manner illustrated on Fig. 5. As the gradient line more closely approaches the vertical, for bottom-poured castings, the more favourable are the conditions for producing soundness by superimposed feeding heads.

It is not suggested that the gradient lines shown on Fig. 5 accurately represent the metal temperature at the different levels of the casting, but the diagram is used—as the author has used it in discussions with operative foundrymen—to indicate the general trend of one effect of bottom-pouring.

The transfer of heat from the metal to the mould is the prime reason for the notable difference in temperature existent between the upper and the lower metal in the mould, and it is reasonable to believe that such transference of heat is, to some considerable degree, related to the duration of contact of metal with mould in the act of pouring. It therefore follows that the lower levels of the mould, closely adjacent to the ingate, are considerably heated and delay the solidification of the metal. Hot spots, so generated, produced two types of defects on the casting under survey: (1) External hot tears at the radius D, and (2) internal shrinkage cavities E (Fig. 4).

All the castings of this type, produced on orthodox methods (Fig. 1) showed these defects at each of the three lower ingates, and while external chilling at the radius eliminated or decreased the incidence of external hot tears, the mid-section unsoundness persisted. Failure to deliver feed metal to the affected parts is believed to be a considerable factor in the combination of causes which promoted the defects.

The Partial Reversal Method

In the revised system of production the castings were gated and headed, and were poured on

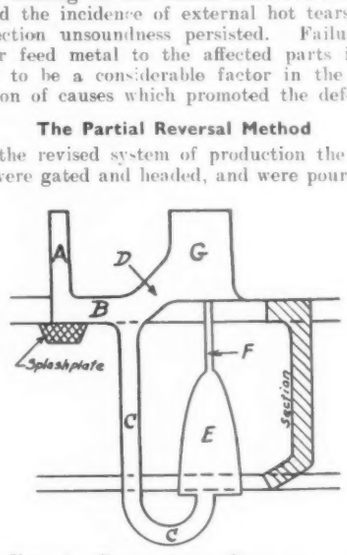


FIG. 3.—EXPLANATORY DIAGRAM OF FIG. 2, WHERE—

A = Primary downgate. B = Crossgate or breaker-gate. C = Lower downgate-horn-gate type produced as half-cores. D = Step-gate—slot-gate type. E = Lower feed head-blind. F = Vent from E to mould joint, and G = upper feed head.

what is called the "partial reversal" method, as indicated on Fig. 2. It should be noted this method prescribes, as essential to its efficacy, that the castings be preferably gated and headed at one end of the long axis, whereas the castings produced on the orthodox method were gated at the side, or parallel with the long axis. Green-sand procedure had to be followed, and the casting was, necessarily, bottom gated to provide for the introduction of the metal in a quiet, non-turbulent manner.

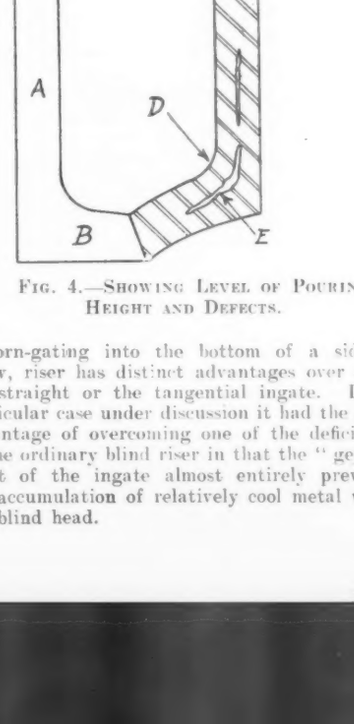


FIG. 4.—SHOWING LEVEL OF POURING HEIGHT AND DEFECTS.

Horn-gating into the bottom of a side, or elbow, riser has distinct advantages over either the straight or the tangential ingate. In the particular case under discussion it had the added advantage of overcoming one of the deficiencies of the ordinary blind riser in that the "geyser" effect of the ingate almost entirely prevented the accumulation of relatively cool metal within the blind head.

Pouring Conditions Prescribed

The angle of pouring prescribed that at least two-thirds of the casting would be produced by metal flowing through the lower ingate, and the speed of pouring was steadily accelerated until it could be seen that metal was flowing through the upper gate. It is believed that, with the indicated gating system, metal ceases to flow through the lower gate almost immediately upon the commencement of delivery through the upper gate, and it therefore follows that the lower levels of metal quickly come to rest, and can proceed with solidification while the upper

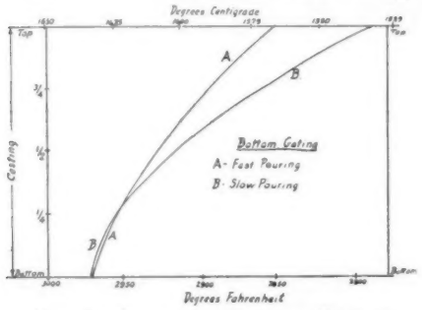


FIG. 5.—SHOWS INFLUENCE OF BOTTOM GATING ON TEMPERATURE GRADIENT.

levels of the mould are being filled. The pouring rate must be such, as in the case of the castings made on ordinary methods, that serious "cold shuts" or ripples are avoided.

On Fig. 6 is indicated the gating and heading system used on the "partial reversal" method. In comparing this with Fig. 4, it must be remembered that Fig. 6 shows the whole of the heading system, whereas Fig. 4 showed only one of the six risers. The two feed heads used on the partial reversal method weighed a little less than half the total amount of head-metal used on the ordinary method.

The actual gate apertures at the lower flange, as shown on Fig. 6, was 9 in. by 1¾ in., which ensured the entry of the metal into the mould proper without serious turbulence. The blind head, disposed immediately above the horn-type ingate, functioned as a balancer to avoid surging within the mould cavity. In visualising the flow of metal in the mould—remembering that the mould is inclined at an angle of 15 deg., the ingate being the low point—it can readily be seen that distribution from a single large ingate must produce practically identical temperature gradients in the lower levels of the casting on each side of the long axis. Vertically, there is a local adverse temperature gradient for approximately two-thirds of the height of the body end-wall adjacent to the gating and heading system; but, as the upper gate begins to function, this adverse temperature gradient in both metal and mould does not become acute.

Approximately one-third of the metal which forms the casting is delivered through the upper gate, the metal delivered by the lower gate tending to build up to an appreciable "head" within the mould above the lower ingate and balancing the pressure at the downgate. Without the "breaker" gate, the upper gate would be late in functioning, and a considerably more acute adverse temperature gradient would be produced adjacent to, and above, the lower ingate.

The upper ingate is definitely a "slot," and is inclined upwards to ensure a mild whirling or eddying motion of metal within the riser. This device is calculated to prevent the formation of a cool upper layer of metal within the riser as the upper levels of the casting are poured. If an ordinary flat ingate is used at the base of the upper head, it is found that very little eddying occurs in the riser while the upper levels of the mould are being filled. Consequently, when both mould and riser are filled—the top of the riser, in the case under discussion, being several inches higher than the high point of the casting at the other end of the mould—there may be several inches of relatively cool metal at the top of the riser, lying over the hotter metal in the lower part of the riser. This is a local adverse temperature gradient which can be avoided by using a slot gate.

Pouring Details

The vents will seal themselves if they are of proper number, size and shape, and the mould may be "reversed" as soon as the ladle moves away. The mould is located approximately in balance on the rocking blocks or bar, and, the wedges being removed, may be reversed through an angle of about 30 deg. to produce an angle of rest of 15 deg. Moulds of considerable size may be manipulated, but the larger moulds, containing castings weighing upwards of 26 cwts., usually demand the services of a crane.

At the "angle of rest," the casting is in the "feeding" position, where gravitation may amplify the effect of whatever favourable temperature gradient has been produced in pouring and reversing the angle of the mould. The adverse temperature gradient in the lower levels of the section shown in Fig. 6 is taken care of by the blind riser, which is placed in a superior position by the reversal of the mould, and by the favourable temperature gradient of the upper levels of the casting plus the superimposed feed head.

This casting taken, as an example for discussion at such length and in such detail, is not one which presents potentialities for the production of a perfect temperature gradient in both mould and metal, but it does present an opportunity for the citation of the successful application of the temperature gradient theory whereby controlled directional solidification was attained and commercially sound castings produced in a foundry which theretofore had experienced some considerable trouble and loss in making such pieces.

It might be argued that, if the heading and gating system used on the partial reversal method had been employed along with orthodox "pouring on the flat," the temperature

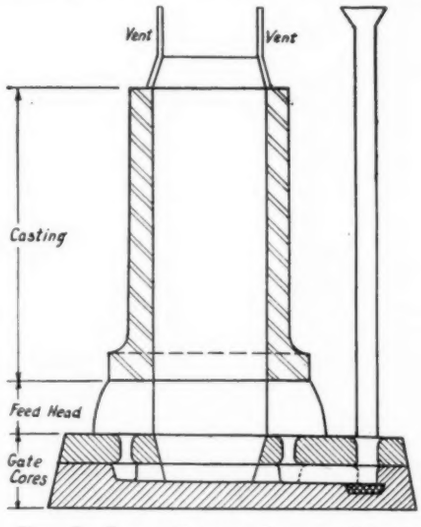


FIG. 7.—LINER CASTING LENDING ITSELF TO THE TOTAL REVERSAL METHOD.

gradients requisite to the production of a sound structure would have been secured without the trouble of "reversing" the mould. Such an argument seems cogent, but it can here be stated that the argument was advanced and the method tried. It was not entirely successful, and it was demonstrated that without the reversal method larger feed heads were required. Even with these larger heads the body wall section adjacent to, and above, the lower ingate was not as sound as when the reversal method was used.

The Total Reversal Method

In steel-foundry practice the most favourable temperature gradient in both metal and mould may be attained by a system of operation that has been called "the total reversal method." Within limitations prescribed by the available equipment this method is productive of very definite economies, on certain types of castings, and at the same time promotes a degree of integral soundness of structure unattainable by ordinary methods.

The example chosen for description is a liner of the design shown on Fig. 7. Normally, such a casting—which has to be machined all over

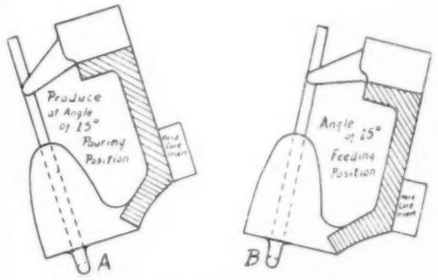


FIG. 6.—THE PARTIAL REVERSAL SYSTEM OF CASTING.

and must also be of uniform internal soundness—would have to be made pronouncedly tapered in section, tapering from heavy section at the top to light section at the bottom. Such a provision would, in turn, demand additional expense in machining off the excess metal.

The casting, as shown on Fig. 7, is a hollow cylinder having almost uniform wall thickness from collar to end. The feed head is annular in form and the gating system is produced in two cores. The upper core, in the pouring position, provides ten ingates, while the lower core contains the annular distributor gate, which is connected to the base of the downgate by a double cross gate. The downgate is either tile (stopper sleeves may be used) or is made of special cores. A solid pattern, with feed head pattern and the print for the gate cores firmly attached, makes practicable the very simple one-part moulding method.

After the pattern is drawn, the mould cleaned, the centre core inserted and the gate cores positioned—these acting as centralising cores for the centre core—a baseplate is firmly clamped on, and the mould turned over into the pouring position, as shown in Fig. 7. As the mould is to be completely reversed after pouring, it is necessary to affix a cover plate or board. This must be provided with holes or slots to allow free venting of the mould atmosphere. The pouring operation—predicated by experience—applies metal as hot as practicable and a pouring rate as slow as practicable. These provisions produce in metal and mould the greatest practicable temperature gradient which, after the mould is reversed through an angle of 180 deg., bringing the head into its proper position to deliver feed metal, presents a metallurgical picture akin to that of a tapered ingot—big-end up—in a well-designed ingot mould provided with a hot-top or brick head.

With the casting in the reversed position after pouring, the lower levels of the metal are cool, and are in contact with cool mould, while the upper levels, particularly in the head, will be maintained in a fluid condition for a considerable length of time by reason of the heat of the mould with which they are in contact. In constructing a diagram to indicate the progress of solidification for such a casting in such a mould, using Brearley's method of inscribed lines, the lines would not be drawn parallel with the mould faces, but would, rather, incline toward each other as in an elongated V.

(To be concluded.)

XUM

Slag Inclusions in Steel

It is well known that chemical methods for the determination of non-metallic inclusions of steel, although accurate, are tedious and costly to apply, with the result that the steelworks chemist and metallurgist have devoted much time to the development of physical methods of examining such inclusions. The most rapid of the various physical methods available is the microscopic examination of polished sections of steel samples, the success of which depends on the investigator's experience and ability to recognise the many types of inclusions met with and the changes their appearance is subject to with variations in chemical composition. F. KANZ, in the "Mitteilungen des Forschungs-Instituts der Vereinigten Stahlwerke," has investigated one important phase of this work and endeavoured to arrive at the equilibrium conditions existing between iron, oxygen, silicon, calcium and phosphorus in steel.

Nature of Inclusions

Inclusions in steel may consist of a wide variety of compounds, and with the exception of the sulphides are produced by the interaction of non-ferrous elements with the oxygen dissolved in the iron. The principal oxides formed are those of manganese, silicon and phosphorus, those of the first-named being difficult to detect under the microscope owing to the ease with which they form mixed crystals with the oxides of iron, the resulting chemical changes not being discernible from the appearance of the crystals. This consideration led Kanz to omit an examination of these compounds in his investigations, although he has placed due weight on calcium inclusions, since in the majority of steelmaking processes the slags are predominantly limey and give rise to calcium inclusions. Alumina and magnesia inclusions are also important, and research on these is to be included in a further Paper by the author.

In his investigations, Kanz used samples consisting of compressed powder made by sintering at 1,200 to 1,450 deg. a series of mixtures composed of electrolytic iron, iron oxide containing 13 to 16 per cent. oxygen, silica, lime and phosphorus pentoxide. A small part of each sample was melted in a mild-steel crucible, the products obtained corresponding in composition to the most varied types of inclusions. Each sample was then examined as a polished section and by chemical analysis.

Examination of Polished Sections

The polished section examinations showed that accompanying silicon α-iron there may occur, according to the oxygen and silicon percentages, a variety of inclusions, consisting of ferrous oxide, ferro-ortho-silicate ($2FeO.SiO_2$) and silica, either alone or in pairs, such as the first two or last two. The silicate $FeO.SiO_2$ corresponding to the mineral grünerit was not detected. The ferrous oxide is always associated with the highest oxygen and the lowest silicon contents, and the silica with higher silicon content of the iron. The silicon content of α-iron in the presence of ferrous oxide was found to be about 0.6 per cent., which appears to be too high, as other investigations, by F. KÖRBER and W. OELSEN, on the reactions between molten steel and ferrous oxide-silica slags, have indicated much lower values. In general, it was observed that the chemical composition of the inclusions could be readily deduced by examination of the polished sections from the proportions of the phases occurring, since there is no miscibility in the solid state.

In the limey samples, α-iron was found accompanied by ferrous oxide, calcium ortho-ferrite ($2CaO.Fe_2O_3$) and lime. It appears that in the presence of lime the iron contains the lower oxygen, and in the presence of ferrous oxide the higher oxygen. As far as has been observed up to the present, calcium does not dissolve in iron. The present results are not in complete agreement with the observations of E. MARTIN and E. VOGEL, described in the "Archiv für das Eisenhüttenwesen," according to which at low percentages of lime, *i.e.*, between ferrous oxide and calcium ortho-ferrite, a compound of the composition $CaO.9FeO$ may be formed, which also possesses a characteristic microscopic image.

Kanz found in equilibrium with the phosphorus and oxygen-containing α-solid solution both ferrous oxide and an iron phosphate with a composition represented by $2FeO.P_2O_5$. Another metallic component found was iron phosphide Fe_3P, in whose presence, however, ferrous oxide was no longer stable. All phases exhibited an almost complete immiscibility in the solid state, so that the inclusions were readily distinguishable in polished sections. The assumption that ferro-phosphate has a composition represented by $2FeO.P_2O_5$ is not in agreement with recent investigations on the system $FeO.P_2O_5$ described by H. WENTRUP in a thesis submitted to the Technische Hochschule, Berlin, for this author has shown the existence of the compound $3FeO.P_2O_5$. It may therefore be assumed that, after the formation of ferrous oxide, this phosphate is first formed, and the higher phosphate $2FeO.P_2O_5$ is only obtained when the steel contains relatively higher percentages of phosphorus, a conclusion confirmed by microscopic examination of polished sections.

Optical Temperature Measurements on Molten Iron and Steel

Report No. 216 of the Heat Economy Bureau of the Verein deutscher Eisenhüttenleute, by F. BLAUROCK, published in the "Archiv für das Eisenhüttenwesen," deals in detail with optical methods for measuring the temperatures of molten iron and steel. The Report is conveniently divided into three parts: Part I discusses the modern application of the optical method to measuring the temperatures of molten iron and steel, reviewing recent literature on total and partial radiation pyrometry, spectral pyrometry, and the errors associated with partial-radiation pyrometers, conclusions being drawn for the improvement of optical temperature measurements in steelworks from systematic experiments. Part II deals with improvements and refinements in the method in order to realise a greater accuracy and reliability, and outlines the experimental work carried out to this end. Part III deals with the practical application of the method, and, in addition to practical instructions, describes and reproduces a series of temperature record charts evolved by the Heat Economy Bureau for procuring a systematic record of all temperature measurements carried out on tapping blast furnaces, cupolas, mixers and on converters, high-frequency furnaces, open-hearth furnaces and cup tests.

A comparison of total and partial radiation pyrometry shows that only the latter offers practical possibilities for measuring the temperatures of molten iron or steel, especially from points outside the furnace bays. Pyrometric methods based on comparative black-body radiation measurements, although theoretically quite practicable, do not enter into the question owing to the lack of suitable apparatus and instruments. The main disadvantage of the optical method is that in most cases no definite data are available of the emissivity, and hence of the temperature correction required for the point of measurement in focus. From a review of previous research and by an exchange of views between different works, the author concluded that the chief drawbacks of partial-radiation pyrometry could be eliminated or at least largely palliated by:—(1) Employing a filter of a colour with a wave-length shorter than red; (2) measuring two colours in succession, using the heated filament pyrometer; and (3) adopting a more precise procedure of measurement in the standard red band.

Measurements in the green band confirmed the deductions drawn from the literature. For this colour the relative sensibility of the eye is greater than for red, while the emissivity also appears to increase, at least slightly, with a reduction in wave-length. The temperature correction for wave-length is thus 20 per cent. lower for green than for red. By taking successive observations in the red and green, corrections for other factors can also be deduced with very accurate instruments.

Previous knowledge on optical temperature measurement in steelworks is co-ordinated and considerably amplified in this Report, both as regards procedure and calculation, but standard values for the emissivities of pure iron containing no oxide and of iron in a state of oxidation could not be obtained, as the values at the surface fluctuated between 0.4 and 1. At the most, two groups of values could be distinguished, 0.4 to 0.68 (dark) and 0.68 to 1 (bright), for even with accurately-fixed measuring points and under apparently equivalent conditions, the emissivity might fluctuate between both limits of each of these groups, although for practical purposes the fluctuations may be regarded as being narrow enough to assume certain fixed values. Whether it is best to focus a dark or a bright spot is a question which can only be determined from case to case, although it should be noted that a dark spot always corresponds to a non-oxidised state and a bright spot may be due to either oxidation or reflexion or both.

In the author's preliminary experiments, observations were also made on the stability of the oxide or slag coating of cast iron between 1,360 and 1,500 deg. It was found that this coating disappears at high temperatures, the latter varying within certain limits with the manganese and silicon contents.

Alloy-Steel Bars

The Air Ministry has issued material specification D.T.D.261, covering alloy-steel bars (not exceeding 2½-in. dia.). We append some of the more important clauses.

Steel to this specification may be used for working parts, such as cams, etc., where a high degree of hardness is required coupled with freedom from distortion after quenching.

Chemical Composition.—(*a*) The chemical composition of the bars shall be:—Carbon, not less than 0.85 nor more than 0.95 per cent.; silicon, not more than 0.5 per cent.; manganese, not more than 1.7 per cent.; sulphur, not more than 0.05 per cent.; phosphorus, not more than 0.05 per cent. Any of the following elements may be present at the option of the steelmaker:—Nickel, not more than 0.25 per cent.; chromium, not more than 0.6 per cent.; vanadium, not more than 0.35 per cent.; molybdenum, not more than 0.6 per cent.; tungsten, not more than 1.0 per cent.

Heat-Treatment.—(*a*) All bars shall be supplied in the softened condition. (*b*) Parts made from material to this specification shall be hardened by heating to a temperature not exceeding 820 deg. C. and quenching in oil. The material shall then be tempered at a suitable temperature to give the required hardness value.

Hardness Test.—The heat-treated parts shall be submitted to a diamond pyramid (or other approved) hardness test. If the diamond pyramid hardness test is adopted, the test shall be carried out in accordance with British Standard Specification No. 427. The values obtained must comply with the following:—Diamond pyramid hardness* (or equivalent on the scale of the method adopted) not less than 672.

* The hardness value specified can be obtained easily in bars of 2½ in. dia. or width across flats. The hardness number obtainable in smaller sizes of bar is proportionately greater.

Steel Castings, with Special Reference to Alloy Steels

By DR. W. H. HATFIELD, F.R.S.

(*Concluded from page* 46.)

Peculiarities of the Different Foundry Steels

The data collated in Table IV are of practical importance to the foundryman, but there are in addition one or two other essential properties of steels which lend themselves less readily to quantitative measurement. The most important of these is probably "fluidity." When handling this wide range of alloy steels in the foundry, due account must be taken of the peculiarities of each steel, and each composition commands its own technique.

Dead soft magnet steel lacks fluidity, although medium-carbon steels possess good fluidity and high-carbon steels are characterised by extreme fluidity, but have a greater tendency towards "blowing" than lower-carbon steels. The greatest care must, therefore, be taken in drying and venting the moulds. The 1½ per cent. manganese steels possess only fair fluidity, and, owing to a slightly increased coefficient of contraction in the solidification range, they are more liable to hot pulling. Whilst ordinary carbon-chromium steels possess reasonable fluidity, nickel-chromium steel tends to be sticky, and the addition of molybdenum accentuates this tendency. The molybdenum steels, especially the higher-carbon alloy, possess reasonably good fluidity, but allowance should be made in moulding for the increased contraction. The manganese-molybdenum steel castings should, for the same reason, be moulded with care; and it is a feature of great interest in connection with this steel, that it appears to have an unusually high liquid contraction; there is an unusually large shrinkage of the metal between the casting temperature and the beginning of solidification, and for this reason large heads must be allowed for.

The high-carbon, 1 per cent. chromium, wear-resisting steels have quite good fluidity, and are reasonably free from hot pulling; but the 14 per cent. and 30 per cent. chromium corrosion- and heat-resisting steels are more sticky.

FIG. 6.—0.40 PER CENT. CARBON STEEL. ANNEALED AT 900 DEG. C. × 200.

FIG. 7.—0.45 PER CENT. CARBON, 1.4 PER CENT. MANGANESE STEEL. AS CAST. × 200.

FIG. 8.—0.45 PER CENT. CARBON, 1.40 PER CENT. MANGANESE STEEL. ANNEALED, 900 DEG. C.; OIL-HARDENED, 870 DEG. C., AND TEMPERED, 650 DEG. C. × 200.

Finally, the 13 per cent. manganese wear-resisting steel and the various high chromium-high nickel corrosion- and heat-resisting steels are all austenitic in character. They all have a high coefficient of contraction on solidification, which means that care and knowledgeable understanding is required to prevent hot-pulling. These austenitic steels have a high coefficient of expansion and contraction when solid, which in turn means that a further contraction of considerable magnitude takes place on cooling from the solidus to room temperature. It is, therefore, general practice to strip these castings when still red hot, and so relieve the metal of the constriction imposed upon it by the sand.

Sands and Moulds Used for the Different Types of Special Steel Castings

For the lightest sections, green-sand or skin-dried moulds are usually employed; and great care should be taken in the preparation of the sand to give high permeability, and permit the free escape of gases from the mould. For high-class castings of light section oil sand is, however, on the whole to be preferred. These general principles are to some extent over-ruled by consideration of the quality of steel being cast.

High-carbon steels, for instance, are liable to "blowing," and for this reason they should never be cast in green-sand moulds; and care should be taken to see that the moulds are properly dried. The same remarks apply, of course, to the high carbon-chromium wear-resisting steels and, in some measure, to the other alloy steels, with the notable exception of the austenitic manganese and 18/8 "Staybrite" types of steel. A very high finish is obtained on castings of light section in these latter qualities, using green-sand or skin-dried moulds.

For castings of heavier section dry-sand moulds are generally used for both carbon and alloy-steel castings; whilst for the heaviest work a very strong clay-bonded sand or compo. is usually employed in this country. A large grain size is necessary to give mechanical strength, and high refractoriness is, of course, essential, since the greater mass of metal involved means that the mould remains at higher temperatures for a longer time. Complex sections, such, for

FIG. 9.—MANGANESE-MOLYBDENUM STEEL. AS CAST. × 200.

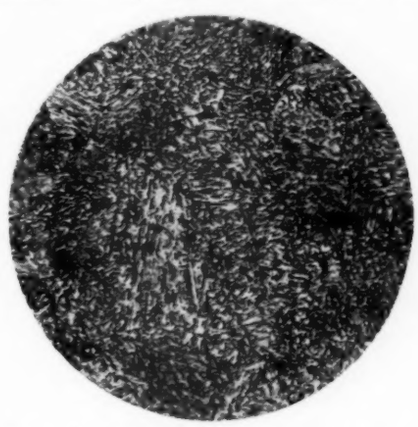


FIG. 10.—MANGANESE-MOLYBDENUM STEEL. ANNEALED 900 DEG. C., FURNACE COOLED TO 650 DEG. C., REHEATED TO 870 DEG. C., AND AIR-COOLED. × 200.

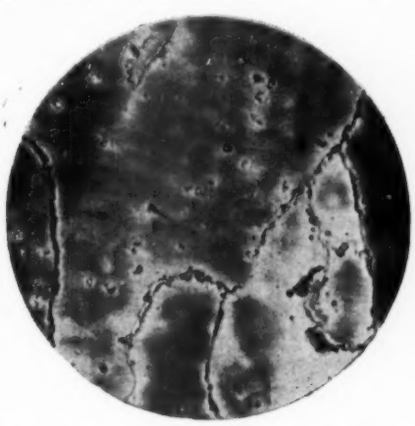


FIG. 11.—12 PER CENT. MANGANESE STEEL. AS CAST. × 200.

example, as frames, bolsters and drag boxes, owing to their intricacy of section, require a special moulding technique combining oil-sand cores for machine faces, green-sand cores to permit of easy contraction and green or skin-dried moulds.

This leads the author to consider another aspect of the choice of sand. Internal cores and mould construction must always be planned to allow for the contraction of the steel on cooling from the beginning of solidification to the temperature of stripping. This contraction varies slightly from one alloy steel to another, and is of greatest importance in the austenitic chromium-nickel corrosion and heat-resisting steels and the 13 per cent. manganese wear-resisting alloy. These steels, besides having a high contraction on solidification, contract substantially on cooling. All cores must, therefore, be made from a sand which is sufficiently weak to yield to the contracting steel, and similarly care must be taken that "pulls" are not produced at the junction of flanges and webs with the body of the casting.

Carbon-chromium steels, 1½ per cent. manganese steels, nickel-chromium, and high-chromium stainless and heat-resisting steels, need the necessary care to counter the possible effects of their tendency towards air-hardening, accentuated by varying thickness of section. For this reason it is sound practice to strip and charge them into the annealing furnace whilst still hot.

It is also essential to strip the austenitic steel castings at the earliest possible moment and so relieve the stresses set up in the casting due to its somewhat high contraction. Heads and risers should be cut off whilst it is still red hot, and all cores removed, so that, when the casting is quenched, the effect of quenching may penetrate right through to the innermost parts.

Fig. 12.—12 per cent. Manganese Steel. Annealed and Water-Quenched from 1,000 deg. C. × 200.

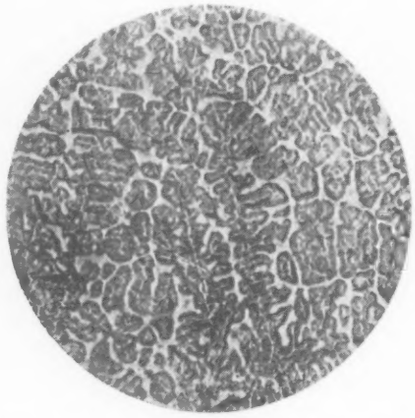


Fig. 13.—14 per cent. Chromium Stainless Steel. As cast. × 100.

Fig. 14.—14 per cent. Chromium Stainless Steel, Oil-Hardened at 970 deg. C. and Tempered at 700 deg. C. × 200.

Perfect Castings

Metallurgical science necessarily plays a leading part in the modern steel foundry. The first requirement in the production of a perfect casting is a supply of clean and fully-deoxidised steel. Although it is theoretically impossible to reduce the oxygen content of steel to zero unless the whole procedure is carried out *in vacuo*, the great strides made in the technology of steel-making during the last decade or two renders it possible to approach closely to this condition.

Then the mould itself must have been properly prepared, and there are one or two considerations not already mentioned worthy of a moment's attention. The box must be of sufficient size to give an adequate thickness of sand between it and the casting; and strengthening bars must not be too near to the incoming hot metal. In addition to the mould itself, the cores should be efficiently "vented," a point which is sometimes overlooked; and if there are several internal cores together, the vents must be linked up. Precision in moulding, the checking of sizes and the position of cores are essential to the production of perfect castings.

Much controversy rages over the relative merits of stopper and lip pouring. In favour of the former is conservation of heat in the ladle, absolute steadiness of the stream (if the nozzle be properly set) and cleaner steel; whilst lip pouring has the advantages of greater flexibility and control over the rate of flow of the metal and avoidance of high ferrostatic pressures.

Each method has its applications, but if the metal is poured in a steady stream into the mould at the correct rate and temperature, without surging inside the mould or splashing outside it, it is immaterial which method is employed.

The casting temperature is critical for three reasons. It must be high enough to give suffi-

Table IV.—*Physical Properties of Various Types of Foundry Steels.*

Class.	Type of steel.	Coefficient of expansion, 20/700 deg. C.	Coefficient of expansion, 20/400 deg. C.	Thermal conductivity. C.G.S. Units.	Magnetic properties.	Air-Hardening Characteristics.	Tenacity at very high temperatures soon after solidification.
Carbon Steel	0.20 per cent. C	0.0000148	0.0000134	0.130/0.110	Magnetic	None	Normal.
„ „	0.30 per cent. C	0.0000148	0.0000133	0.120/0.105	Magnetic	None	Normal.
„ „	0.40 per cent. C	0.0000148	0.0000133	0.120/0.095	Magnetic	None	Normal.
„ „	0.60 per cent. C	0.0000147	0.0000133	0.110/0.075	Magnetic	None	Normal.
„ „	0.75 per cent. C	0.0000146	0.0000132	0.100/0.070	Magnetic	None	Normal.
Alloy Steel	1½ per cent. Mn + 0.25 per cent. C	0.0000148	0.0000133	0.090/0.085	Magnetic	Very slight	Normal.
	1½ per cent. Mn + 0.45 per cent. C	0.0000148	0.0000132	0.090/0.085	Magnetic	Very slight	Normal.
„ „	Ni-Cr	0.0000148	0.0000133	0.105/0.080	Magnetic	Present	Normal.
„ „	Ni-Cr-Mo	0.0000148	0.0000133	0.100/0.080	Magnetic	Marked	Slightly increased.
„ „	C-Cr	0.0000148	0.0000133	0.110/0.080	Magnetic	Present	Normal.
Rustless Steel	14 per cent. Cr Stainless	0.0000124	0.0000115	0.045/0.040	Magnetic	Marked	Normal.
„ „	18 per cent. Cr, 2 per cent. Ni Stainless (S.80 type)	0.0000120	0.0000113	0.040/0.035	Magnetic	Marked	Normal.
Acid-Resisting Steel	18 per cent. Cr, 8 per cent. Ni Stainless ("Staybrite" type)	0.0000185	0.0000175	0.035/0.030	Non-magnetic	None	Somewhat increased.
Heat-Resisting Steel	26 per cent. Cr, 10 per cent. Ni	0.0000171	0.0000159	0.030/0.025	Non-magnetic	None	Somewhat increased.
„ „	20/25 per cent. Cr, 8/12 per cent. Ni, 3/4 per cent. W	0.0000171	0.0000159	0.030/0.025	Non-magnetic	None	Greatly increased.
„ „	30 per cent. Cr	0.0000120	0.0000111	0.035/0.030	Magnetic	Marked	Normal.
„ „	Ni-Cr-Fe Alloys	0.0000119	0.0000133	0.025/0.020	Non-magnetic	None	Greatly increased.
High Permeability Steel	Low C	—	—	—	Magnetic	None	Normal.
High Temperature Steel	Mo + 0.20 per cent. C	0.0000148	0.0000134	0.130/0.110	Magnetic	None	Slightly increased.
	Mo + 0.30 per cent. C	0.0000148	0.0000133	0.120/0.100	Magnetic	Very slight	Slightly increased.
Shock-Resisting Steel	Mn-Mo	0.0000148	0.0000133	0.090/0.080	Magnetic	Very slight	Slightly increased.
Wear-Resisting Steel	C-Cr, Wear-Resisting	0.0000148	0.0000133	0.110/0.080	Magnetic	Marked	Normal.
Wear-Resisting Steel	Austenitic, 13 per cent. Mn	0.0000198	0.0000192	0.030/0.025	Non-magnetic	None	Normal.

cient fluidity to the steel to enable the casting to be run. It must be low enough to prevent fusion of the sand to the casting. It must be low enough to give fine crystal structure and minimum heterogeneity.

The first point is self-explanatory, and in connection with the second an interesting example might be quoted. A certain standard magnet casting weighed 7 cwts. and had a thickness of about 2 in. When it was run in less than 70 sec., the sand was burnt on and the skin was bad; but when the pouring time was more than

FIG. 15.—18 PER CENT. CHROMIUM, 8 PER CENT. NICKEL STEEL. AS CAST. × 50.

70 sec., the casting had a perfect blue skin. All factors other than temperature were under complete control, and the temperature is inversely proportional to the pouring time.

Much work has been carried out in recent years on the heterogeneity of steel ingots, and one point which is very clearly indicated is that the lower the casting temperature, the less is the segregation. The other important effect of temperature on structure is that the lower the casting temperature, the smaller is the grain size.

It might perhaps be thought that, because every casting is heat-treated, the primary structure is of no importance; but this is a fallacy. The primary structure is more or less outlined by a fine network of non-metallic matter, according to the quality of the liquid steel, and,

FIG. 16.—18 PER CENT. CHROMIUM, 8 PER CENT. NICKEL STEEL. AIR-COOLED FROM 1,150 DEG. C. × 200.

although the primary grain structure is replaced by a much finer structure during normalising, this network cannot be entirely removed by heat-treatment. In a casting, therefore, the fine-grained structure produced by heat-treatment is superposed upon and within the coarser network associated with the primary structure; and in the perfect casting the pouring temperature should, therefore, be as low as is compatible with a fluid and easily-run steel. It is for this reason that the author has laid stress upon the freezing point of different steels and has correlated the information in Table III, because it is only by studying their freezing ranges, in conjunction with fluidity, design of mould and weight of steel to be cast, that the optimum casting temperature can be arrived at.

Macro- and Micro-Structure

The primary structure formed by the steel on solidification is not only coarse, but is the cause of the low ductility and in certain cases brittleness associated with the "as-cast" condition. A prolonged heating at a temperature well above the upper critical point of the steel gives opportunity for the diffusion of elements which either as elements or compounds enter into solid solution in the steel, and subsequent cooling through the critical range results in recrystallisation and the formation of a refined structure.

The temperatures of the critical points are affected by the composition of the steel, and in Fig. 4 a number of curves, illustrating the comparative thermal phenomena, are presented. Heat-treatment must always be based on the carefully-determined thermal data on each steel. The coarse nature of the primary crystallisation as well as the fine structure produced by heat-treatment, is illustrated in Figs. 5 to 16, which give a comparative study of different foundry steels in the condition "as cast," and after the heat-treatment normally applied to put them into the optimum service condition.

TABLE V.—*Effect of Heat Treatment on Plain Carbon Steels.*

	0.20 per cent. Carbon steel		0.40 per cent. Carbon steel	
	As cast	Annealed	As cast	Annealed
M.S. tons per sq. in.	34	32	42	40
Y.P. tons per sq. in.	22	16	22	21
Elong. per cent.	17	30	4	18
R. of A. per cent.	15	50	4	24

Were any further evidence needed to show the fundamental importance of even simple heat-treatment, the figures in Table V are convincing.

Conclusion

Within the limitations as regards the space at his disposal, the author has attempted to give some idea of the various special steels applied to foundry practice; has attempted to present and correlate essential data needful for a proper working-out of foundry technique; and, so far as space allowed, has dealt with the applications and the properties which determine these applications.

The subject is an extensive one, and in many directions much intensive further investigation is necessary to explore fully the various possibilities of service in the steels now available in cast form. Much additional research is necessary to confirm and to extend the type of data with which the author has endeavoured to deal. So much is this appreciated by the leading firms that advantage is being taken of the possibilities of collective research with the object of extending fundamental knowledge for the industry.

The Joint Committee of the Iron and Steel Institute and the Federation of British Iron and Steel Manufacturers fully merits the support of each constituent firm in the industry in its determined attempt in this field. The need for filling in the gaps in our knowledge as regards the characteristics of the different steels in the liquid state as affected by varying temperature, and the changes in properties which occur at and following upon solidification, is very real. The author trusts that this Paper may assist in some measure in focussing certain aspects of the matter.

Treatment of Foundry Burns

By J. COLE and H. T. ANGUS (Parkinson Stove Company).

Burns produced by molten metal have long been known to be exceedingly difficult to treat satisfactorily, as there is an almost invariable tendency for even small burns to become septic and spread to many times their original area. Observation over a period of years have revealed the following facts:—

(1) Burns from molten metal received on the hand, fore-arm, head, neck and leg, very rarely give serious trouble.

(2) Burns received due to molten metal falling inside the boot invariably give trouble, small burns of the order of $\frac{1}{4}$ in. to $\frac{3}{8}$ in. dia. frequently spreading to such an extent that the man is incapacitated for periods up to 24 weeks. Possible reasons for this are:—(*a*) The possible introduction of poisonous material through the burning of wool or leather in close contact with the wound; (*b*) the poor circulation available in the foot, and the fact that in use the burns are constantly kept moist by perspiration in the boot; (*c*) the difficulty of maintaining the wound in a thoroughly aseptic condition owing to the fact that the foot is constantly in the moulding sand, and dirt tends to penetrate the dressings. In all probability the real cause of the trouble lies in (*b*) above, and for this reason dressings of picric acid are unsuitable, as picric acid poisoning very readily develops with limited circulation and moist skin. Tannic acid treatment is only suitable for application when it is absolutely certain that the wound is first of all aseptic, and can subsequently be maintained so. Ointments of any description are quite unsuitable owing to the ease with which they pick up dirt from the foundry. Carron oil is also open to the same objection, and in any case is difficult to maintain sterile in storage.

For the past 18 months in the foundry of the Parkinson Stove Company, Limited, the following treatment has been adopted with conspicuous success:—Gauze soaked in a saturated solution of sodium bicarbonate in water with mercuric chloride to a concentration of 1 in 5,000 is applied to the burn, the dressing covered with cotton wool and lightly bandaged. This treatment is carried out preferably twice a day, until suppuration ceases, after which plain dressings of gauze soaked in Eusol are sufficient to complete healing. There appears to be an "incubation" period of 6-7 days before spreading commences. Using this treatment, the burns are ordinarily completely healed in two or three weeks without the patient staying away from work.

Eusol, which is essentially a solution of hypochlorous acid, is very readily prepared from chloride of lime as follows:—1,150 c.c. distilled water; chloride of lime ($CaOCl_2$), 7.1 grams; boric acid (H_3BO_3), 3.5 grams.

The chloride of lime is stirred into the distilled water and allowed to stand for two or three minutes, after which the solution is filtered thoroughly and boric acid added. This solution may be stored in the dark for many months in a well-stoppered brown glass bottle, from which two or three days' supply may be drawn at a time for general use.

German Ferro-Alloy Control

Decree No. 11 of July 8 of the German Iron and Steel Control Board, which regulates the whole German iron and steel trade, requires all undertakings to render returns by July 22 as to their output, trade and stocks of ores and ferro-alloys containing chromium, tungsten, uranium, molybdenum and titanium, all other ores falling within Import Tariff No. 237 and all ferro-alloys within Import Tariff Nos. 317c, 766b, 869b1, and 869b2. The usual penalties apply for rendering false returns or withholding relevant information.

XUM

Company Meeting

Buell Combustion Company, Limited

MR. JOHN A. AGNEW'S ADDRESS

The eighth ordinary general meeting of the Buell Combustion Company, Limited, was held on July 17 at the Institute of Chartered Accountants, Moorgate Place, E.C.

MR. JOHN A. AGNEW (chairman of the company) presided, and in the course of his speech said:—

Last year I informed you that we had acquired an exclusive licence to manufacture and sell within the British Empire the Van Tongeren system for dust precipitation, and on October 27, 1934, we purchased, on most favourable terms, the British Empire rights of the Buttner system of drying, for which system we previously held, in conjunction with Messrs. Edgar Allen & Company, Limited, Imperial Steelworks, Sheffield, an exclusive licence to manufacture and sell within the said territory. These two important businesses were acquired after careful investigation of the technical merits of the respective equipments and on convincing proof from many sources that they possessed commercial potentialities of appreciable magnitude. Having decided upon this expansion of our interests, it was an essential corollary that these two businesses should be developed upon lines best calculated to bring about satisfactory trading results, a task not altogether immune from peculiar difficulties, which in our case were augmented by the fact that the Van Tongeren system was industrially unknown and unproved in this country in its major use, whilst little was known of the Buttner system outside those concerns which had already installed it. In carrying our policy into effect, it became increasingly evident that our staff was insufficient and that before business could be handled in these processes to the extent desired, it was essential to create a staff specialised in such diversified applications as came within the range of drying and precipitating equipment. This staff development work has necessitated collective and intensified action, since it has been necessary to carry it out simultaneously with the initiation and conclusion of contracts with the subsequent commissioning of plants and conducting of guarantee tests.

Formation of American Company

With the formation of the Buell Engineering Company, Inc., New York, a considerable amount of work has devolved upon our staff in preparing essential drawings, correlation of technical data and the initiation of engineers from the United States into the details of equipment to be handled by them. Whilst these services have been entirely unremunerative during the year under review, I am confident that the activity and interest created to date by our American company among many influential potential users of our plant is a good augury for future benefit to our company.

I have referred to the fact that the Van Tongeren system, although unproved in this country, is capable of extensive industrial exploitation, and as the keystone to efficient building up of this phase of our business we have devoted the past year to the establishment of demonstration plants in twelve centres in this country, each plant dealing with the precipitation of different materials, whilst similar equipments have been installed in Estonia, Rhodesia, India and Australia, dealing with such diverse materials as carbon solids, ash dust, cement dust and gold-bearing dust from ore-roasting furnaces. I feel confident that the development of the system on these lines will ultimately prove of appreciable value to your company.

Buttner Drying System

As regards the Buttner drying system, notwithstanding the time devoted to staff requirements as previously referred to, a number of contracts have been entered into with important clients, who not only readily appreciated the marked advance in drying technique as is represented by this system, but were alert to the possibilities of extending its use into fields hitherto closed to the ordinary standard drying equipment. In these days of sudden changes, it seems imprudent to prophesy; we shall, however, be disappointed if, in view of the importance of the drying installations already effected and working satisfactorily, we do not witness during the ensuing year a satisfactory return from this important part of our business. Incidentally, I would mention that in many instances we are called upon to dry and/or separate materials which have hitherto not been subjected to treatment by such means. Inquiries of this nature have resulted in negotiations extending over an appreciable time, and to obviate this we have equipped a test station at Sheffield with model Buttner dryers and Van Tongeren separators, and the results have exceeded expectations in that they have induced certain clients to take decisions in favour of our plant more expeditiously than would have been the case had these units not been available for testing purposes. Indications are that the commercial benefits from these units will be greatly enhanced in the future, thus serving to prove conclusively the correctness of the decision to incur the expense entailed in equipping and servicing the test station.

Pulverised Coal Firing

Although we continue to meet with inertia, and in some cases apathy, in our endeavours to develop the sales of our pulverised-coal-firing system, we have been successful during the year in obtaining contracts for pulverised-coal-firing equipment on Lancashire boilers, water-tube boilers, cast-steel-annealing furnaces, straightening furnaces and metal-melting furnaces, all of which plants have satisfactorily fulfilled the guarantees given to our clients. It was our belief that by convincing the controllers of certain industries of the efficiency and marked economies that are permissible of attainment with our system, a substantial increase in this phase of our business would have resulted. We appear to have done our part, but, for reasons not at present apparent, the increase has not materialised during the year under review. You may rest assured, however, that every endeavour is being made to augment sales in this equipment, and as indication thereof our pulverised-fuel department has devoted an appreciable portion of its time, in collaboration with Messrs. Rickett, Cockerell & Company, in developing the sales of pulverised coal in bulk for central-heating and industrial purposes in Greater London. A direct result of their efforts has been the erection and commissioning of a large central pulverising station at Deptford, from whence coal in a pulverised form is transported in specially-designed road tank vehicles to users in the London district. Our first plant under this development has been commissioned in a block of service flats in Piccadilly, and I am advised that the plant is operating most satisfactorily and showing appreciable savings compared with oil fuel previously used. It is natural to anticipate that some time must elapse before the full value of such development work will be reflected in our balance-sheet, but the interest shown in this plant and resultant inquiries fortify my belief in the future of this system of firing.

Microniser Reduction System

I referred briefly in my last speech to the Microniser reduction system, of which we have world's rights for coal and metalliferous ores. I am pleased to state that the considerable amount of testing and research work on the two Microniser units installed at our test station has been so successful as to lead us to enter into negotiations for expanding our interests in the Microniser reduction system in the British Empire and certain Continental countries for materials other than coal and metalliferous ores. Licences entered into upon most advantageous terms by our licensors with important American companies for the use of the Microniser on materials other than coal and metalliferous ores have been put before us, and these confirm our belief that this system has commercial possibilities of a far-reaching nature, in that no other system of reduction at present available can effect the resultant fineness which is possible with the Microniser and is so essential in many branches of industry.

Resulting from our negotiations, a syndicate has been formed to exploit the Microniser in various countries and to demonstrate the advantages of the system on certain materials: this syndicate is preliminary to the formation of a separate company. In the latter your company will hold an important interest.

In order more easily to deal with the sale of this company's products in the United States of America, a company to which I have already referred was formed at the end of last year with its registered offices at 70, Pine Street, New York, which is also the office of the Gold Fields American Development Company, Limited. As partners with us in this company we have the Gold Fields American Development Company, Limited, and the Struthers Wells Titusville Corporation. The authorised capital of the company is $250,000, but of this it is only proposed at present to issue $120,000. Of this amount your company is subscribing for $50,000 in cash and is receiving in addition $20,000 worth of shares as consideration for certain American rights, which were passed over to the new company. The balance of $50,000 is being subscribed for in cash by the Gold Fields American Company, Limited, and the Struthers Wells Company in equal proportions. It is intended that the manufacture of the plant should be carried out by the Struthers Wells Company, who have most up-to-date works and are in every way equipped to carry on the manufacture of this type of plant. The new company's organisation is now only just being completed, but already there are evidences of sound remunerative business being placed before the company.

Technical Director's Work

It is, I feel, necessary for me to say a word or two regarding the work being carried out by Dr. Blythe, the technical adviser to the company, and his very capable staff. By his colleagues on the board the amount of really serviceable work performed by Dr. Blythe is well understood and thoroughly appreciated, but I would like shareholders to realise that the ultimate success of this company will be due very largely indeed to the efforts now being so strenuously made by the technical director and his assistants.

The report and accounts were adopted.

Russian Shipbuilding Order for Durham

The Soviet Government have placed with the Furness Shipbuilding Company, Limited, Haverton Hill-on-Tees, an order for seven cargo vessels for use in the timber-carrying trade. The vessels will each be just under 4,000 tons dead-weight, 320 ft. in length, and fitted with triple-expansion engines, and will be specially strengthened for steaming through ice floes. Construction will begin as early as possible as delivery has to be made within 12 months. The order, which is one of the largest secured by North-East Coast firms since the war, will provide work directly for about 800 men for a year at Haverton Hill-on-Tees.

Relationships in Cast-Iron Test Results

(*Continued from page* 63.)

cast" at 18 in.; and the 1⅝-in. bars were from top and bottom halves of 26-in. bars machined and tested at 12 in., previously tested "as-cast" at 24 in. The difference due to shorter span would be much less than the increases shown, and does not affect direct comparisons between the same size bars from different mixtures.

The largest mean increase is associated in each case, for the same machining, with the higher-strength iron—which confirms the curves of Fig. 7—although in some individual bars of medium strength iron gains of up to 31 per cent. occur. In no case, even when machined from 1.65-in. dia. to 1.3-in. dia. in a 14-ton iron or to 1-in. dia. in the 18-ton iron, did the results from the machined bar fail to exceed the result of the bar tested "as-cast."

No further results are available in this series, but they are sufficient to show that machining of high-strength bars is to be recommended if the real strength is to be determined, and in the event of an oversize bar having to be machined to comply with specification, no reduction of modulus of rupture is to be expected, although, of course, the breaking load will be lowered.

(*To be concluded.*)

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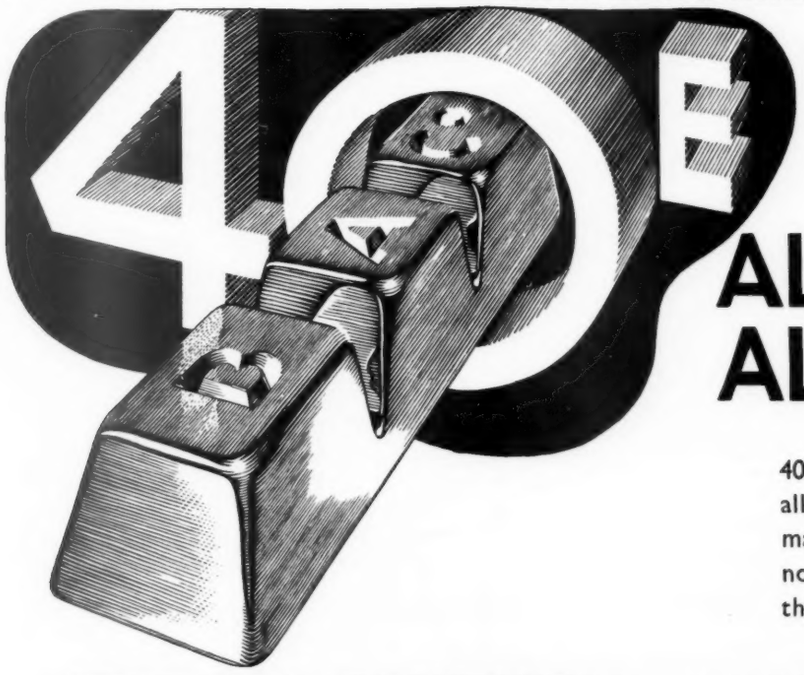

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F.T.J. 25.7.35

ARMSTRONG WHITWORTH "PLUS" TYPE CHIPPING HAMMERS

This range of hammers is the outcome of practical tests carried out in the Fettling Shop, and we claim that for their weight and size these hammers produce a better job in less time.

The adjoining illustration depicts a battery of Armstrong Whitworth "Plus" type chipping hammers, operating on a large 26-ton bedplate casting, in one of the many foundries in this country which have standardised on our tools for all types of foundry work.

May we arrange for our Demonstration Van to call at your works with a view to your testing our tools on site?

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This Week's News in Brief

Trade Talk

AN ORDER for 29 sets of Caprotti valve gear has been received by Messrs. William Beardmore & Company, Limited, Dalmuir, for fitting to locomotives now being built for the East India Railway and the North-West Railway of India.

A COLLECTIVE CELEBRATION of Glasgow Fair holidays was arranged by the employees of Messrs. Henry Wiggin & Company, Limited, Argus Works, Thornliebank, Glasgow, when a party of over 200 travelled from Glasgow Central Station on Friday night to Blackpool to meet fellow-employees from Birmingham. The party, which included many ladies, spent a happy week-end at the seaside resort, returning to Glasgow on Monday.

THE STANTON IRONWORKS COMPANY, LIMITED, near Nottingham, has received a large order for large-diameter spun-iron pipes, to the value of over £50,000, from the Municipality of Skoplje, Yugo-Slavia. The City Council of Skoplje, when placing the order, stated that, although keen offers were received from Continental competitors, the order was given to the Stanton Company in view of the high reputation enjoyed by British material in their country.

THE SIXTH INTERNATIONAL CONGRESS for Scientific Management was opened by the Duke of Kent at the Central Hall, Westminster, last week. It was attended by approximately 2,000 delegates, representing 34 countries. Over 200 papers for discussion were received through the national committees. The business sessions continued until Thursday, and visits to numerous factories and other establishments took place on Friday and Saturday. The Prince of Wales, who is patron of the Congress, attended the closing session on Thursday, and spoke on the work of the congress. Among those who took part in the Congress were the Earl of Dudley, Sir Robert Hadfield, Sir Valentine Crittall, Lord Gainford, Mr. L. E. Mather, Mr. W. L. Hichens, Sir Felix Pole and other industrialists.

THE ANNUAL EXCURSION of the Staffordshire Iron and Steel Institute was held on July 10, when a visit was made to the works of Messrs. Steel, Peech & Tozer and the United Strip and Bar Mills, Limited. The party consisted of 53 members and friends and included Mr. J. T. Wright (President) and Mr. T. G. Bamford (Vice-President). The party was entertained to luncheon by the company, the President expressing thanks on behalf of the Institute for the opportunity of visiting the works and for the hospitality. He said that some recent results achieved by subsidiaries of the United Steel Companies must be very gratifying to the management and staff. At the Appleby Works, a furnace operating the Talbot hot-metal continuous process, had produced no less than 2,950 tons of steel ingots in a normal working week. This was a fitting answer to those pessimists who regarded British practice as inefficient and behind that of Continental competitors. In the absence of Mr. A. Williamson, Mr. Percival Smith (production manager) replied.

Thermal Insulation of O.-H. and Electric Furnaces

(*Concluded from page* 60.)

basic 450-kg. electric furnace, however, furnished complete data; before hearth insulation the heat losses in this furnace were so great that certain high-alloy steels could not be produced in it. When the hearth was insulated, the losses were so far reduced that not only was this drawback remedied, but the output of the furnace was also increased by 33 per cent. with a reduction in current consumption of 15.5 per cent.

To calculate the heat losses, the authors also carried out temperature measurements at different levels in the hearth, thus arriving at the average hearth temperature as well as at the temperature fluctuations in the hearth with varying periods of melting. These measurements showed the great extent to which fluctuations fall off with the depth, the damping in some cases being so great that when the furnace was idle during holidays the lower parts of the hearth did not cool at all. The authors have found in every case that some economy can be achieved in open-hearth furnaces by rational insulation of the hearth.

Personal

MR. ROBERT W. KENNARD has been elected a director of the Falkirk Iron Company, Limited.

MR. F. I. SMEDLEY has resigned from the office of general manager of the Butterley Company, Limited, and is being succeeded by Mr. H. FitzHerbert Wright, son of Capt. FitzHerbert Wright. Mr. Smedley's services are being retained in a consultative capacity.

MR. DAVID MILLAR has been presented with a gold chain by the members of the Kilmarnock branch of the Boilermakers' and Iron and Steel Shipbuilders' Society, and with the Society's gold medal, in recognition of long service on behalf of the executive committee of the district. He has held all the offices in the branch for 30 years.

MR. JOHN MCEACHEN, foreman moulder at Messrs. Cameron & Roberton, Limited, Southbank Iron Works, Kirkintilloch, has retired after 54 years' service with the firm. Mr. McEachen, who has been foreman for over 40 years, received a number of gifts from his fellow-employees in the works, by whom he is held in high esteem. He has for many years taken an active part in the work of the Scottish Branch of the Institute of British Foundrymen, and is well known in local foundry circles. He recently celebrated his 72nd birthday.

Obituary

MR. RALPH W. BERTIE, who for many years was associated with the firm of Messrs. George Stephen & Son, iron and steel merchants, Dundee, has died, aged 67.

THE DEATH OCCURRED very suddenly, at his home in Overtown Road, Newmains, on July 13, of Mr. James Reid, who for many years had been in the employment of the Coltness Iron Company at Newmains.

Contracts Open

Iraq, August 5.—15,000 ft. of 12-in. lap-welded steel spigot and socket pipes and special fittings, for the Bagdad District Water Board. The Department of Overseas Trade. (Reference T.Y. 5,047.)

Johannesburg, September 9.—Two new steam tugs, for the South African Railways and Harbours Administration. The Department of Overseas Trade. (Reference T.Y. 5,041.)

Teifi-Side, August 8.—Spun, cast-iron and cement-asbestos pressure pipes of from 2 in. to 4 in. dia., with valves, hydrants, standpipes and other fittings, for the Rural District Council. Mr. R. Jones, engineer, Llandyssul. (Fee £2 2s., returnable.)

New Company

(From the Register compiled by Jordan & Sons Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

George Allart, Limited, 146, Sherborne Street, Ladywood, Birmingham.—Capital £5,000 in £1 shares. Brassfounders. Directors: G. Allart and F. Allart.

Company Reports

Head, Wrightson & Company, Limited.—Profit, £30,352; brought in, £1,718; debenture interest, £6,750; directors' fees, £750; additional reserve for doubtful debts, £2,000; depreciation of fixed plant and machinery, £20,000; carried forward, £2,571. Although the trading position is better, the directors consider that the state of the company's finances does not permit the resumption of the payment of dividends. The amount available has, therefore, been used for depreciation, thereby strengthening the position of the company.

Ruston & Hornsby, Limited.—Debit balance of £74,130 brought in has been transferred to capital suspense account. Balance on trading account for the year, after charging depreciation and after making provision for losses on exchange, and other contingencies, £88,276; dividend from associated company, Ruston-Bucyrus, Limited, £18,600; directors' fees, £1,561; interest on debentures and debenture stocks, £25,050; credit balance, £80,265. The directors are able to recommend the payment of the uncancelled balance of the arrears of preference dividends, namely, on the 5 per cent. preference stock for one year to June 30, 1935, and on the 6 per cent. "B" preference stock for six months to June 30, 1935. This will absorb £20,500, leaving a balance of £59,765 to be carried forward. During the past year opportunity was taken of giving notice to redeem the £250,000 6 per cent. debentures on June 30, 1935, and replacing them by an issue, at par, of a like amount of 4½ per cent. debenture stock, 1965-75.

Armstrong Whitworth Securities Company, Limited.—Profit and loss account for the year shows that the general administrative charges exceeded the income from dividends on investments, interest and income tax recovered by £1,856, to which has to be added debenture interest and directors' fees amounting to £38,515, resulting in a loss of £40,372. The subsidiary companies have again, in the aggregate, incurred trading losses during the year, and provision for such losses amounting to £283,343 has been debited to profit and loss account, making a total debit balance of £1,195,216. Considerable improvement in the heavy engineering business began during the year under review, and though the change in conditions did not take place early enough to admit of more satisfactory results being reflected in the final figures for the year, the provision for trading losses was, nevertheless, reduced by over £200,000, or more than 40 per cent. Arrangements have been made to repay the whole of the outstanding 4 per cent. mortgage debenture stock, in accordance with the powers reserved to the company under the trust deed. Notice of redemption has accordingly been issued, and the debenture stock will be repaid at 102½ per cent. on December 30 next. This step having been decided upon, the directors have considered it desirable to write down certain over-valued and/or intangible assets in order to clear up the balance-sheet. Further, shipbuilding prospects being so unfavourable, the Shipbuilders' Company was sold during the year under review to the National Shipbuilders' Security, Limited. Satisfactory orders for steam locomotives were obtained by the Engineers' Company during 1934. The Ironfounders' Company continued to suffer from the general depression, though further improvement in the chilled-rolls business was achieved. Craven Bros. (Manchester), Limited, report a profit for 1934 of £20,490, after adequate provision for depreciation.

Bright Nickel Plating

By adding a chemical material to any ordinary nickel electro-plating solution of proper composition, the Harshaw Chemical Company, Cleveland, U.S.A., has developed a process for producing bright nickel plating which does not require buffing and polishing before a plating of chromium can be applied. It is said that the new process offers savings of 60 to 80 per cent. in the cost of finishing chromium-plated products. Another advantage is that parts not previously suitable for chromium plating, because their shape made proper polishing after nickel plating impossible, can now be chromium finished without difficulty. The chemical which is added to the nickel bath is an organic material, the nature of which is not divulged. Supplied by the Harshaw company under licence arrangement, the chemical agent is added to the bath as a 1 per cent. solution, therefore, its cost is comparatively low.—"Steel."

12 GRADES OF FREE-RUNNING FOUNDRY IRON

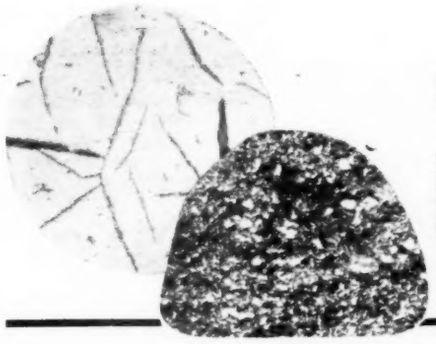
From the 33 grades of pig-iron produced in the Stanton Company's modern blast-furnaces, the foundryman can select an ideal iron for any type of casting. The various grades are grouped into three brands—Stanton, Holwell and "W'bro'" (Rixon's). All these irons will carry a good percentage of scrap, and produce sharply-moulded castings with smooth, clean surfaces free from blow-holes. They are available in notched pigs already broken in halves—a feature which facilitates handling and reduces labour costs.

Stanton and Holwell Foundry Irons are very similar in analysis. These free-running irons are particularly suitable for castings such as radiators, electrical goods, gas cookers, rainwater pipe, and all types of casting which are to be vitreous enamelled.

STANTON LOW-PHOSPHORUS FOUNDRY PIG IRON

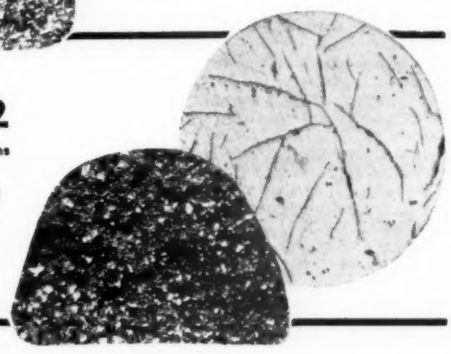
is particularly suitable for the heavier types of general engineering casting. Of similar analysis to Scotch iron, it produces high-strength castings which can easily be machined.

This iron can be supplied within limits of small margins of Silicon, the average analysis being: Silicon 2.0-4.0; Manganese 0.9-1.0; Sulphur 0.03; Phosphorus 0.73-0.78; Total Carbon 3.7.



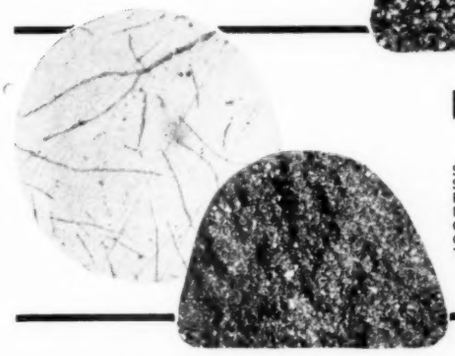
FOUNDRY No. 1

	Stanton %	Holwell %	Rixons %
Silicon	3.5	3.4	3.39
Sulphur	0.015	0.01	0.010
Phosphorus	1.36	1.4	1.62
Manganese	0.45	0.44	0.37
Graphitic Carbon	3.5	3.52	3.61
Combined Carbon	0.15	0.1	0.05
Total Carbon	3.65	3.62	3.66



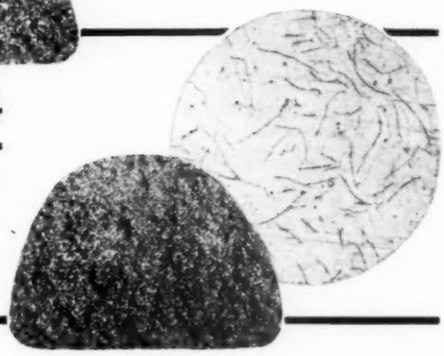
FOUNDRY No. 2

	Stanton %	Holwell %	Rixons %
Silicon	3.2	3.2	3.35
Sulphur	0.015	0.015	0.010
Phosphorus	1.36	1.39	1.68
Manganese	0.45	0.44	0.33
Graphitic Carbon	3.49	3.3	3.47
Combined Carbon	0.2	0.16	0.07
Total Carbon	3.69	3.46	3.54



FOUNDRY No. 3

	Stanton %	Holwell %	Rixons %
Silicon	2.91	3.0	3.29
Sulphur	0.025	0.02	0.025
Phosphorus	1.35	1.38	1.65
Manganese	0.46	0.44	0.34
Graphitic Carbon	3.35	3.16	3.52
Combined Carbon	0.3	0.3	0.12
Total Carbon	3.65	3.46	3.64



FOUNDRY No. 4

	Stanton %	Holwell %	Rixons %
Silicon	2.45	2.65	3.25
Sulphur	0.05	0.47	0.045
Phosphorus	1.35	1.36	1.65
Manganese	0.44	0.38	0.32
Graphitic Carbon	3.15	2.88	3.19
Combined Carbon	0.4	0.46	0.12
Total Carbon	3.55	3.34	3.31

STANTON PIG IRONS

The largest producers of Pig Iron (for Sale) in Great Britain

THE STANTON IRONWORKS COMPANY LIMITED, Near NOTTINGHAM

Raw Material Markets

Holiday interruptions have reduced the flow of business both in pig-iron and steel and will continue to do so over the next few weeks, but, generally, steady conditions continue. Greater forward buying activity has been noted this week in pig-iron, which may be attributed to precautionary covering by users against the possibility of an increase in prices of common irons, following the recent upward movement of hematite values.

Pig-Iron

MIDDLESBROUGH.—Much forward buying of foundry pig-iron has occurred in the Cleveland market and consumers have been covering their requirements for a few months ahead. The output is nearly all sold for the next two or three months and should industrial needs expand further, the output may have to be increased. The ironmasters have very little iron for export purposes. All home prices for foundry and forge qualities remain firm and unchanged.

The recent increase in delivered prices of East and West Coast hematite left the prices of East Coast hematite on Tees-side and the North-East Coast unchanged, but they have now been raised by 2s. The revised quotations for No. 1 East Coast hematite are as follow:—Delivered Middlesbrough, 71s. per ton; delivered North-East Coast, 73s. 6d.; Scotland, 77s. 6d.; Lancashire and Sheffield, 78s. 6d.; Birmingham, 81s. 6d. per ton. The rise does not appear to have affected the demand for hematite to any appreciable extent.

LANCASHIRE.—Very little alteration is reported from this market. Good quantities of iron are being taken up by the light-castings makers and also by the heavy electrical, machine-tool, and a number of specialised branches. Replacement has taken place in moderate quantities and most of the consumers are fairly well covered over the next few months. Quotations for delivery in the Lancashire price zone are as follow:—Staffordshire, Derbyshire and Lancashire brands of No. 3 foundry iron, 74s. per ton; Northamptonshire, 72s. 6d.; Scottish foundry, 81s. 6d. to 82s. 6d. East Coast hematite for delivery equal to Manchester is now quoted at from 77s. 6d. to 78s. 6d., according to quality, and West Coast is at 81s. per ton.

MIDLANDS.—Consumers have commenced covering their future requirements and during the last few days large quantities of Midland pig-iron have been booked. The large ironfounders are only moderately well occupied, but the smaller light-castings manufacturers are very well employed. No change in the controlled prices for Midland brands of foundry iron has been noted, the rates remaining at 67s. 6d. for Northants No. 3 and 71s. for Derbyshire, Lincolnshire and North Staffordshire No. 3. Last week an improvement in the general engineering trade was reported, and this has been maintained. Quotations for the better grades of iron used by the engineering trade are from 72s. to 80s. for medium-phosphorus quality, and from 85s. to 90s. for low-phosphorus. The price of refined pig-iron ranges from £5 7s. 6d. to £7 per ton, delivered. Owing to the majority of the users of hematite pig-iron having covered their requirements before the recent advance in price, very little new buying has been done. The controlled price for West Coast hematite No. 3 is 80s. 6d. per ton delivered this district.

SCOTLAND.—The annual holidays have reduced business considerably. No change in prices has been made. Founders in the Falkirk district have resumed work after their holidays and English foundry iron is being delivered again. The prices of Cleveland iron are unchanged. For steel-making irons the latest prices are:—Mixed numbers Scottish hematite, 71s.; ordinary mixed numbers West Coast hematite, 75s.; ordinary mixed numbers East Coast hematite, 77s. 6d.; basic, British and Indian, 70s. (less 5s. rebate), all delivered steelworks.

Coke

The coke market is still featureless and very little forward buying has been reported. These conditions may alter shortly, as furnace coke has given signs of a stronger position. For delivery in the Birmingham and Black Country district, best Durham foundry coke is at from 34s. to 40s. and Welsh from 31s. to 42s. 6d. per ton.

Steel

Active conditions continue to rule in the steel markets, and the volume of business is considerably larger than is usual at this time of the year, says the official report of the London Iron and Steel Exchange. Consumers are showing a greater disposition to book forward and are probably encouraged to do this by reports of impending price advances in some departments. The weakness of the position is that export trade is poor, and markets which usually buy at this season have displayed little interest. In the semi-finished steel section trading has been quiet; but the producers have large tonnages on their order-books and at the same time are making heavy deliveries to the consuming works. Contrary to expectations, no offers of Continental semi-finished steel have been received for the British market, but it is anticipated that new business in this material will be sought in the near future. Great activity rules in the finished-steel department, although in some districts deliveries have been suspended as a result of the annual holidays. The demand is largely upon home account, and export business shows few signs of expanding.

Scrap

Iron and steel scrap is prominent on the Cleveland market and supplies of heavy melting steel are quickly absorbed by the steelworks at a price of 52s. 6d. per ton. Foundry cast-iron scrap at the same price is also well taken up. Good machinery metal is realising 54s. per ton in some quarters, but the general figure is 55s. Light cast iron is at 43s. per ton delivered works and nominal prices of heavy steel turnings and cast-iron borings are 35s. and 25s. per ton respectively. Business on the South Wales market has fallen off and conditions generally are quiet. Good, heavy cast-iron machinery scrap is in small demand at from 52s. 6d. to 55s., but otherwise there is a slight decrease in prices. Conditions on the Midland market are easy and very little alteration has been reported. Heavy steel scrap in furnace sizes is at 44s. to 45s. and mixed heavy iron and steel is at 43s. to 44s. Heavy machinery, in cupola sizes, is at 55s. to 57s. 6d., good heavy at 50s. and clean light at 47s. 6d., all delivered works. Business on the Yorkshire market remains good and no appreciable alteration has occurred. Mixed wrought iron and steel for basic furnaces is at from 50s. to 52s. 6d. delivered. An active market exists in Lancashire and cast-iron scrap of good machinery quality is on offer at from about 47s. 6d. to 52s. 6d. per ton delivered Lancashire foundries.

Metals

Copper.—Very heavy sales of this metal have taken place in America. On one day alone nearly 24,000 tons were sold. The demand has chiefly been from brassmakers and from the automobile industry. The price of copper in this country has fluctuated very little. The agreement on restriction reached last March is reported, following the meeting of producers held in London recently, as being fully adhered to. It is anticipated that the statistical position of copper will improve further during this year and thus a cheerful outlook may be adopted.

Daily market prices:—

Cash.—Thursday, £31 7s. 6d. to £31 10s.; Friday, £31 16s. 3d. to £31 17s. 6d.; Monday, £31 16s. 3d. to £31 18s. 9d.; Tuesday, £31 16s. 3d. to £31 17s. 6d.; Wednesday, £31 16s. 3d. to £31 17s. 6d.

Three Months.—Thursday, £31 16s. 3d. to £31 17s. 6d.; Friday, £32 5s. to £32 6s. 3d.; Monday, £32 5s. to £32 7s. 6d.; Tuesday, £32 5s. to £32 6s. 3d.; Wednesday, £32 3s. 9d. to £32 5s.

Tin.—An almost farcical position has been reached on the London tin market. On Monday no tin was offered, despite bids of £245 for cash. The backwardation then exceeded £20 per ton. Spot tin continues to be in very short supply. A meeting of the International Tin Committee is not likely to be held for a considerable period; at the last conference no date for a future meeting was arranged.

Day-to-day fluctuations:—

Cash.—Thursday, £234 15s. to £235; Friday, £236 to £236 10s.; Monday, £245, no sellers; Tuesday, £232 10s. to £233; Wednesday, £233 5s. to £233 10s.

Three Months.—Thursday, £224 17s. 6d. to £225; Friday, £224 10s. to £224 15s.; Monday, £224 15s. to £224 17s. 6d.; Tuesday, £223 15s. to £224; Wednesday, £223 15s. to £224.

Spelter.—Although the price of this metal has advanced, it is still in the unusual position of being below that of lead. Consumption has been fairly well maintained, but there is only a moderate current demand from consumers.

Official quotations were as follow:—

Ordinary.—Thursday, £14 2s. 6d; Friday, £14 8s. 9d.; Monday, £14 10s.; Tuesday, £14 13s. 9d.; Wednesday, £14 15s.

Lead.—The price of lead has now reached its peak for the year so far and firm conditions are reported. Demand in this country and also abroad is strong. Deliveries have been booked for a considerable time ahead. Favourable conditions are reported from the United States, where the market has improved a good deal during the last few weeks. The prospects of the metal are very sound.

Day-to-day quotations:—

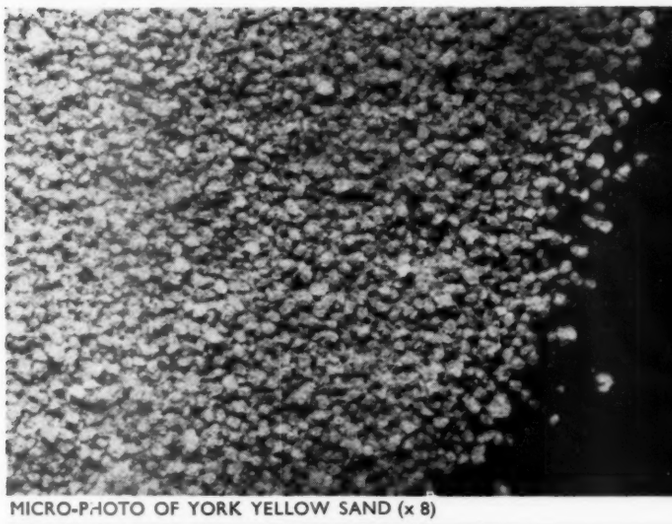
Soft Foreign (Prompt).—Thursday, £14 17s. 6d.; Friday, £15 1s. 3d.; Monday, £15 3s. 9d.; Tuesday, £15 6s. 3d.; Wednesday, £15 6s. 3d.

Catalogue Received

Electric Furnaces. "As is well known, heat-transference at low temperature is mainly dependent on the circulation of air in the form of convection currents—radiation taking little part in temperatures below 500 deg. C." This is a quotation from a 12-page, well-illustrated catalogue issued by Wild-Barfield Electric Furnaces, Limited, of Elecfurn Works, North Road, London, N.7, and sums up the situation which has necessitated the design and exploitation of the forced-air circulation electric furnace. Progress has been such that the air draft is now so nicely balanced that an increased output of the order of 25 per cent. has been attained. The reviewer is rapidly reaching the conclusion that this type of furnace will achieve popularity, for core-baking; inefficiency in the past has been due to "stewing" and a fear of losing a few heat units up the chimney. We advise foundry executives to keep themselves abreast of developments in connection with forced-air circulation electric furnaces.

SILICO MANGANESE SILICO ALUMINIUM
FERRO SILICON 25/30%
CALCIUM SILICIDE
SILICO SPIEGEL
FERRO ALLOYS
J. N. CLIFTON,
53, Victoria Street,
Westminster,
LONDON, S.W.
Telephone: Victoria 1852.
Telegrams: Newcliff, Sowest, London.

Moulders who want a sand with that little extra resistance for casting iron and iron alloys at high temperature, and which will produce a good skin on the casting, will find no better medium than York Yellow Sand. It is well bonded, fine in grain, yet permeable and highly refractory.



YORK YELLOW

MICRO-PHOTO OF YORK YELLOW SAND (× 8)

GENERAL REFRACTORIES LIMITED.

Telephones:	*Head Office:*	*Telegrams:*
Sheffield 22311 (5 lines).	Genefax House, Sheffield.	Genefax, Sheffield.
	London Office:	
London 7361 Temple Bar.	Russell House, Adelphi, W.C.2.	Genefax, Rand, London.
	Glasgow Office:	
Central 5250.	156, St. Vincent Street, C.2.	Genefax, Glasgow.

XUM

RAW MATERIALS—PRICE LIST

(Wednesday, July 24, 1935)

COPPER

	£ s. d.
Standard cash	31 16 3
Three months	32 3 9
Electrolytic	35 0 0
Tough	33 10 0
Best selected	34 0 0
Sheets	62 0 0
India	45 0 0
Wire bars	35 15 0
Ingot bars	35 12 6
H.C. wire rods	39 5 0
Off. av. cash, June	30 16 8 11/19
Do., 3 mths., June	31 4 1 1/19
Do., Sttlmnt., June	30 16 10 3/19
Do., Electro, June	34 7 4 1/19
Do., B.S., June	33 13 1 1/2
Do., wire bars, June	34 13 11 7/19
Solid drawn tubes	10d.
Brazed tubes	10d.
Wire	6d.

BRASS

Solid drawn tubes	9¼d.
Brazed tubes	11¼d.
Rods, drawn	8d.
Rods, extd. or rlld.	4¼d.
Sheets to 10 w.g.	7¼d.
Wire	7¾d.
Rolled metal	7d.
Yellow metal rods	4¼d.
Do. 4 × 4 Squares	5¾d.
Do. 4 × 3 Sheets	5¾d.

TIN

	£ s. d.
Standard cash	233 5 0
Three months	223 15 0
English	233 15 0
Bars	235 15 0
Straits (nom.)	240 5 0
Australian (nom.)	233 15 0
Eastern	233 0 0
Banca (nom.)	236 10 0
Off. av. cash, June	227 14 3 6/19
Do., 3 mths., June	219 10 9 9/19
Do., Sttlmt., June	227 14 5 15/19

SPELTER

	£ s. d.
Ordinary	14 15 0
Remelted	15 0 0
Hard	12 0 0
Electro 99.9	17 6 3
English	15 12 6
India	13 5 0
Zinc dust	18 10 0
Zinc ashes	3 5 0
Off. aver., June	13 16 3 15/19
Aver. spot, June	13 14 8 1/19

LEAD

	£ s. d.
Soft foreign ppt.	15 6 3
Empire (nom.)	16 8 9
English	17 5 0
Off. average, June	13 15 9 33/38
Average spot, June	13 15 6 8/19

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	23 0 0
Do., V.M. ex-whse.	23 15 0
Rods	28 15 0

ANTIMONY

	£ s. d.
English	74 0 0 to 75 0 0
Chinese, ex-whse.	69 0 0
Crude, c.i.f.	25 10 0

QUICKSILVER

	£ s. d.
Quicksilver	11 2 6 to 11 12 6

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£8 17 6
45/50%	£12 15 0
75%	£17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£15 15 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	£33 10 0
4/6% car.	£21 15 0
6/8% car.	£21 0 0
8/10% car.	£21 0 0
Ferro-chrome—	
Max. 2% car.	£34 0 0
Max. 1% car.	£36 5 0
Max. 0.70% car.	£37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/6 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to 11 5 0
76/80% packed	£11 15 0 to 12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/32 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb
Do., under ¼ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£ s. d.	£ s. d.
South Wales—		
Heavy steel	2 15 0	to 2 16 0
Bundled shrngs.	2 7 6	to 2 16 0
Mixed iron and steel	2 10 0	to 2 12 0
Heavy cast iron	2 10 0	to 2 12 0
Good machinery	2 12 6	to 2 15 0
Cleveland—		
Heavy steel	2 12 6	
Steel turnings	1 15 0	
Cast-iron borings	1 5 0	
Heavy cast iron	2 12 6	
Heavy machinery	2 14 0	to 2 15 0
Midlands—		
Light cast-iron scrap	2 7 6	
Heavy wrought iron	2 17 6	
Steel turnings	1 14 0	
Scotland—		
Heavy steel	2 10 0	
Ordinary cast iron	2 12 6	
Engineers' turnings	1 19 6	
Cast-iron borings	1 17 6	to 1 19 0
Wrot-iron piling	2 17 6	
Heavy machinery	2 17 6	

London—Merchants' buying prices, delivered yard.

	£ s. d.
Copper (clean)	26 0 0
Brass	17 0 0
Lead (less usual draft)	12 10 0
Tea lead	9 10 0
Zinc	8 10 0
New aluminium cuttings	66 0 0
Braziery copper	22 0 0
Gunmetal	24 0 0
Hollow pewter	155 0 0
Shaped black pewter	110 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
,, at Falkirk	67/3
,, at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	71/-
Hematite M/Nos.	70/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	75/-
,, d/d Birm.	87/-
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
,, No. 3 fdry.	71/-
Northants forge	63/6
,, fdry. No. 3	67/6
,, fdry. No. 1	70/6
Derbyshire forge	67/-
,, fdry. No. 3	71/-
,, fdry. No. 1	74/-
Scotland—	
Foundry No. 1, f.o.t.	72/6
,, No. 3, f.o.t.	70/-
Hem. M/Nos. d/d	71/-
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	68/6
Lincs forge	64/6
,, fdry. No. 3	68/6
W.C. hematite	86/-
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/-
Clyde, No. 3	82/-
Monkland, No. 3	82/-
Summerlee, No. 3	82/-
Eglinton, No. 3	82/-
Gartsherrie, No. 3	82/-
Shotts, No. 3	82/-

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	9 12 6	to 9 15 0
Nut and bolt iron	7 10 0	to 8 0 0
Hoops	10 10 0	and up.
Marked bars (Staffs) f.o.t.	12 0 0	
Gas strip	10 10 0	and up.
Bolts and nuts, ⅜ in. × 4 in.	14 2 6	and up.
Steel—		
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.	9 5 0	to 9 7 6
Chequer plts.	10 7 6	
Angles	8 7 6	
Tees	9 7 6	
Joists	8 15 0	
Rounds and squares, 3 in. to 5½ in.	9 7 6	
Rounds under 3 in. to ¼ in. (Untested)	8 12 0	
Flats—8 in. wide and over	8 12 6	
,, under 8 in. and over 5 in.	8 17 6	
Rails, heavy	8 5 0	to 8 10 0
Fishplates	12 5 0	to 12 10 0
Hoops (Staffs)	9 7 0	
Black sheets, 24g. (4-t. lots)	11 0 0	
Galv. cor. shts. (,,)	13 0 0	
Galv. flat shts. (,,)	13 10 0	
Galv. fencing wire, 8g. plain	14 10 0	
Billets, soft	5 10 0	and up.
Billets, hard	6 17 6	to 7 2 6
Sheet bars	5 2 6	to 5 7 6
Tin bars	5 5 0	to 5 7 6

PHOSPHOR BRONZE

Per lb. basis.

Strip	9¾d.
Sheet to 10 w.g.	11½d.
Wire	12d.
Rods	11d.
Tubes	13¾d.
Castings	12d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

Per lb.

Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.31
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Malleable, Valley	18.50
Grey forge, Valley	18.00
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37½
Billets	27.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	19/- to 20/-
Durham foundry	19/- to 22/-
,, furnace	16/6 to 17/9
Scotland, foundry	28/-
,, furnace	25/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14	per box	18/2 and up.
,,	28×20	,,	36/4 and up.
,,	20×10	,,	26/-
,,	18¾×14	,,	18/9
C.W.	20×14	,,	15/3 to 15/6
,,	28×20	,,	32/6 to 33/-
,,	20×10	,,	23/- to 23/3
,,	18¾×14	,,	15/6 to 15/9

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£30 0 0 to £31 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.	
July 18 ..	31	7	6	dec. 6/3
„ 19 ..	31	16	3	inc. 8/9
„ 22 ..	31	16	3	No change
„ 23 ..	31	16	3	„ „
„ 24 ..	31	16	3	„ „

Electrolytic Copper

	£	s.	d.	
July 18 ..	35	0	0	dec. 5/-
„ 19 ..	35	0	0	No change
„ 22 ..	35	0	0	„ „
„ 23 ..	35	0	0	„ „
„ 24 ..	35	0	0	„ „

Standard Tin (cash)

	£	s.	d.	
July 18 ..	234	15	0	inc. 40/-
„ 19 ..	236	0	0	„ 25/-
„ 22 ..	245	0	0	„ 180/-
„ 23 ..	232	10	0	dec. 250/-
„ 24 ..	233	5	0	inc. 15/-

Tin (English ingots)

	£	s.	d.	
July 18 ..	235	0	0	inc. 45/-
„ 19 ..	236	0	0	„ 20/-
„ 22 ..	nominal			—
„ 23 ..	233	0	0	dec. 60/-
„ 24 ..	233	15	0	inc. 15/-

Spelter (ordinary)

	£	s.	d.	
July 18 ..	14	2	6	inc. 6/3
„ 19 ..	14	8	9	„ 6/3
„ 22 ..	14	10	0	„ 1/3
„ 23 ..	14	13	9	„ 3/9
„ 24 ..	14	15	0	„ 1/3

Spelter (Electro, 99.9 per cent.)

	£	s.	d.	
July 18 ..	16	15	0	inc. 7/6
„ 19 ..	17	0	0	„ 5/-
„ 22 ..	17	0	0	No change
„ 23 ..	17	5	0	inc. 5/-
„ 24 ..	17	6	3	„ 1/3

Zinc Sheets (English)

	£	s.	d.	
July 18 ..	23	5	0	inc. 7/6
„ 19 ..	23	10	0	„ 5/-
„ 22 ..	23	10	0	No change
„ 23 ..	23	0	0	dec. 10/-
„ 24 ..	23	0	0	No change

Lead (English)

	£	s.	d.	
July 18 ..	17	0	0	inc. 15/-
„ 19 ..	17	0	0	No change
„ 22 ..	17	5	0	inc. 5/-
„ 23 ..	17	5	0	No change
„ 24 ..	17	5	0	„ „

AVERAGE MONTHLY PRICES OF CLEVELAND No. 3 PIG-IRON.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1895	34 7	34 4	34 4	34 8	35 6	35 2	36 1	37 1	38 10	38 6	37 11	37 6	36 3
1896	37 3	38 4	38 7	38 1	37 4	37 4	36 11	36 11	37 11	39 2	40 5	40 5	38 3
1897	41 2	40 4	40 5	39 2	39 7	40 9	39 6	40 5	41 7	42 5	41 5	40 4	40 7
1898	40 9	40 8	40 6	40 0	40 7	39 11	40 4	41 11	43 0	44 11	49 1	44 3	42 0
1899	46 10	47 11	47 9	49 10	55 11	62 10	71 6	65 9	67 7	68 8	70 0	66 9	60 5
1900	67 10	68 10	73 10	76 2	74 2	68 6	69 3	71 4	70 9	67 8	63 6	53 6	68 9
1901	48 0	46 6	45 8	45 5	45 10	44 7	44 6	45 3	45 3	45 3	43 6	43 1	45 3
1902	43 11	46 7	46 9	47 11	48 10	49 7	50 9	52 1	53 8	52 9	50 9	47 11	49 3
1903	47 3	48 9	51 10	49 0	46 1	46 2	46 7	46 8	45 7	43 6	42 10	41 11	46 4
1904	42 3	42 7	43 3	44 7	44 0	42 10	42 9	43 3	43 1	43 9	46 1	48 7	43 11
1905	48 11	48 0	49 6	50 1	51 5	45 6	45 9	47 5	48 8	52 11	52 9	53 3	49 6
1906	53 9	50 1	48 1	48 8	50 2	50 3	50 6	53 0	54 6	56 8	58 6	62 4	53 6
1907	60 4	56 6	54 10	56 0	61 1	58 1	57 8	57 8	55 7	54 8	50 8	50 0	56 2
1908	48 5	49 3	51 7	51 10	51 6	51 2	50 0	51 4	52 0	49 8	49 4	48 11	50 8
1909	48 10	48 1	46 9	47 9	48 4	48 9	48 6	50 5	51 3	51 11	51 2	50 7	49 4
1910	51 10	51 3½	51 7½	50 10	49 10	49 2	48 10	49 8½	49 3½	49 7½	49 0½	49 10	50 4
1911	49 11½	49 2½	48 5	46 11	46 4	46 6	46 11½	47 4	47 0	46 7	47 4½	48 1	47 7
1912	50 0	49 5½	51 1½	53 7½	54 4	55 1	57 5½	64 6½	61 7½	66 8½	67 8	68 0	58 8½
1913	66 11½	63 8½	64 8	67 11½	66 3	56 9½	56 3½	55 8	55 4	53 0	50 1	50 4	58 10
1914	50 11	51 5½	51 0½	51 4½	51 6	51 6½	51 5	52 3	51 5	50 1	50 3	53 0	51 4½
1915	55 7	56 6	61 0	66 7	65 2	66 10	65 4	66 0½	65 3	65 11	69 10½	75 7½	65 7
1916	80 2	91 6	87 4½	86 10	82 6	82 6	87 6	87 6	87 6	87 6	87 6	87 6	85 10
1917	87 6	87 6	87 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	95 0	92 3
1918	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0
1919	95 0	95 0	95 0	95 0	152 6	160 0	160 0	160 0	160 0	160 0	160 0	160 0	137 8
1920	175 0	175 0	187 6	200 0	208 0	217 6	217 6	221 0	225 0	225 0	225 0	225 0	209 3
1921	222 6	195 0	150 0	126 0	120 0	120 0	120 0	136 3	127 0	120 0	110 0	100 0	137 4
1922	92 6	90 0	90 0	90 0	90 0	90 0	89 0	87 3	92 6	92 6	92 6	91 3½	90 7½
1923	94 6	108 9	125 6	129 4½	128 5	136 0	128 1½	121 11	97 1½	97 0	100 0	100 0	110 0½
1924	99 10	97 3½	91 9	93 9	91 9	89 10½	87 9	85 0	82 5½	80 2½	81 9	81 9	88 7½
1925	80 4½	78 10½	78 0	78 3	76 0	73 10½	71 7½	69 10½	68 1½	66 7½	66 0	66 10½	72 10½
1926	69 4½	70 0	70 0	70 0	72 6	75 10½	86 7½	90 0	93 10½	117 10	120 0	99 0	88 3
1927	85 0	83 1½	81 0	80 0	73 9	70 0	70 0	68 9	67 6	67 6	66 10½	65 0	73 2½
1928	65 0	65 0	65 6	66 0	66 0	66 0	66 0	66 0	66 0	66 0	66 0	66 0	65 9½
1929	66 0	66 9	67 0	68 1½	69 5	71 10½	72 9	72 6	72 6	72 6	72 6	72 6	70 4½
1930	72 6	72 6	70 0	67 6	67 6	67 6	67 6	64 6	63 6	63 6	63 6	63 6	66 11½
1931	59 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 7
1932	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6
1933*	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6
1934*	62 6	65 0	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	66 10½
1935*	67 6	67 6	67 6	67 6	67 6	67 6	—	—	—	—	—	—	—

* Delivered Middlesbrough area. Prior to 1933, prices were f.o.t. furnaces.

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PATTERNMAKER, 30, seeks change of position as Foreman or Under-Foreman with prospects. Sound technical and works experience. Three years dwg. and est. offices. Interview willingly. Keen.—Apply Box 324, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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WANTED, an experienced man to take charge of a large cupola plant melting 1,000 tons of cast iron per day. Apply, giving age and experience, to THE STANTON IRONWORKS COMPANY, LIMITED, near Nottingham.

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MOULDER, age 33, in small foundry, desires similar position in large foundry centre, Midlands or London areas preferred. Competent workman, technical knowledge. (264)

YOUNG MOULDER requires position as Moulder or in charge. Excellent experience iron (repetition work), brass, aluminium and special alloys. Technical training. (265)

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Room Plants, sizes 12 ft. x 12 ft., 12 ft. x 9 ft. and 6 ft. x 6 ft., made up in cast-iron sections.

Barrel Plants, 30 in. dia. x 36 in. long and 30 in. dia. x 18 in. long rotary barrels.

Cabinet Plants, in sizes 4 ft. x 4 ft. x 4 ft., 36-in. dia. and 30-in. dia. operators' cabinets.

Most of the above by Tilghman and complete with Air Compressors.

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Hydraulic ACCUMULATOR, casing 30' high, 7' dia.; carrying 51 tons; 12" ram dia., 20' stroke.

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30"×40" "Shockless" TABOR rollover.

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T.B. 4 Tilghman sandblast barrel plant, complete. Size of barrel 60" × 40".

T.B. 1 Tilghman sandblast barrel 30"×20".

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